Journal of Chemical Education

Published by

Division of Chemical Education of The American Chemical Society

Easton, Pa.

Entered as Second-class Matter, January 31, 1924, at the Post Office at Easton, Pa., under the Act of March 3, 1879. Acceptance for mailing, at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized January 31, 1924

Vol. III **September, 1926** **No. 9**

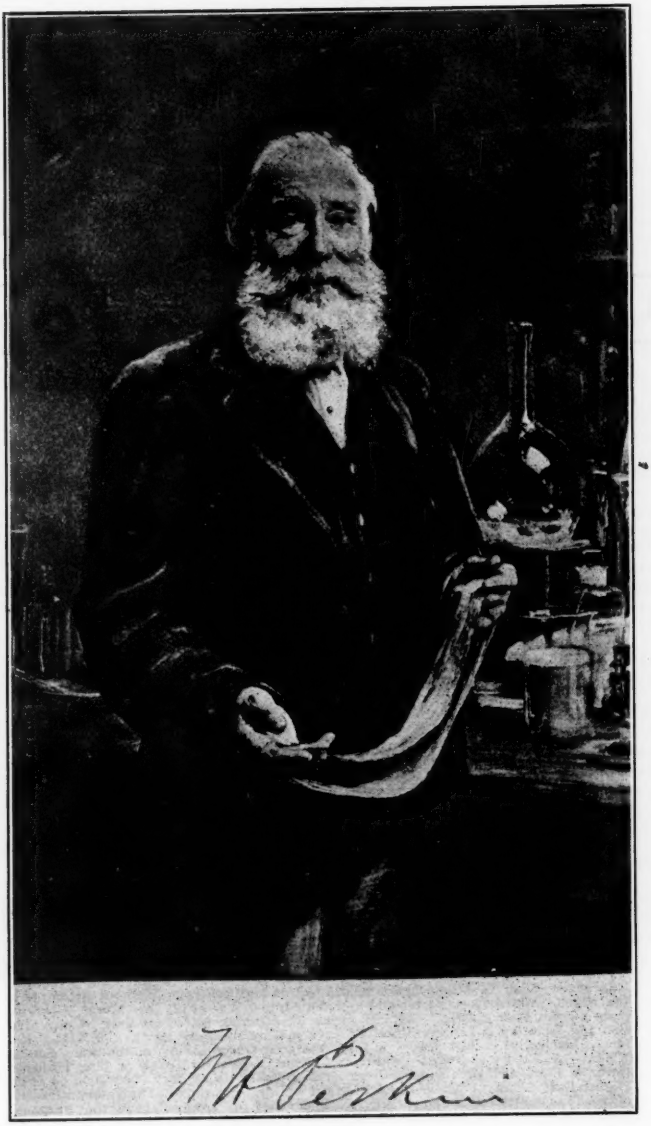
CONTENTS

	Page
Frontispiece	968
Editor's Outlook	969
Growth of the Dyestuffs Industry. R. E. Rose	973
Some Phases of the Work of the Bureau of Chemistry on Dust Explosions in Industrial Plants. David J. Price	1000
The Relation of Chemistry to the Enrichment of Life. Elizabeth Dawson	1018
The Relation of Chemistry to Agriculture and Forestry. Euphemia Clark	1024
The Relation of Chemistry to the Home. Geo. B. Crump	1029
The Relation of Chemistry to Health and Disease. Vincent A. McKivergan	1033
The Use of Chemistry in Our National Defense. Wallace Herrick	1039
Chemistry in Relation to the Rubber Industry. Margaret Cox	1044
The Influence of Early Science on Formative English. P. H. Hembdt	1051
A New Periodic Table of the Elements. C. J. Monroe and W. D. Turner	1058
The First Lecture in General Chemistry. A. T. Bawden	1066
A Qualitative Analysis Puzzle. Carl Otto	1071
Chemical Digest:	
Training the Chemist	1073
Research	1074
Success?	1077
Abstracts	1080

The Value of Intelligence Tests; "Seeing" with X-Rays; What Is an Element?; The Present Status of the Theory of Relativity; A Study of the Vocabulary of Scientific Articles Appearing in Daily Newspapers; The Growth of Crystals; Rustless Steel and Flexible Glass 5000 Years Ago?; The Element of Atomic Number 61; Illinium; The Periodic System, Chemical Bonds, and Crystal Structure; The Use of Intelligence Tests by Universities; Educational Publicity in the Teachers' College; Iron in Antiquity; The Isotopes of Sulfur; The Origin of Petroleum; The Pupil and the Student; Why Not Give Students a Contact with Research Work?; Sulfuric Acid—"The Warhorse of Industry"; Kinds of Examinations; Advantages and Defects of Examinations; The Determination of Traces of Mercury. Quantitative Determination of Mercury in Presence of Organic Matter; Electron Displacement in Carbon Compounds. Derivatives of Benzene; Contact Catalysis and the Mechanism of Chemical Reactions; Education—Man vs. Mass; Character-Education and Scientific Method; Attempts to Fractionate Mixed Isotopes of Lead and the Atomic Weight of This Metal; Observations on the Rare Earths. XXIII. Element Number 61. Part One. Concentration and Isolation in Impure State; Observations on the Rare Earths. XXIII. Element Number 61. Part Two. X-Ray Analysis; Observations on the Rare Earths. XXIV. A Theory of Color; Vitality in College Courses for Teachers; The Transmutation of Elements; Potassium and the Heat of the Earth; X-Ray Identification of the Higher Fatty Acids; Chemical and Physical Action at Surfaces; The Present Position of the Transmutation Controversy; High Frequency or "Ironliss" Induction Furnaces; Electrons, Atoms, and Molecules; A Hydrometer for Solids; Some Recent Contributions of Chemistry to Medicine

Recent Books	1089
Conventions—Go to Them!	1091
A Card Is Coming to You	1092

BOSTON UNIVERSITY
COLLEGE OF LIBERAL ARTS
LIBRARY



WILLIAM PERKIN

EDITOR'S OUTLOOK

Revitalizing Education

EDUCATION, we are frequently told, is approaching, if it has not already reached, a crisis. The age when one man could master the fundamentals of the sum-total of human knowledge has long ago passed into history. No one is now so optimistic as to expect that any one man can hope to make even a general survey of existent knowledge, and a lifetime scarcely suffices for the mastering of one limited branch of it. The human mind, still bound to the slow process of evolution which has brought it to its present stage of development, contemplates with dismay the suddenly augmented and ever more rapidly expanding field with which it is called upon to cope.

Educators confronted with this poser have had recourse mainly to evasion. While there is still talk of liberal education and general culture, by far the greater number of students register in specialized courses made up in turn of sub-specialized subjects which the student may supplement with certain electives mainly at his own discretion. There is little attempt at coördination. Even assuming that the student selects, or has selected for him, a course which includes the elements of a liberal education, it is left to him to synthesize the heterogeneous mass into a coherent whole.

True, some efforts have been made to mitigate the deplorable aspects of this situation by the insertion into the curriculum of special courses designed to correlate and homogenize the student's miscellaneous gleanings. The results are probably about as satisfactory as those arising from the administration of pepsin to a dyspeptic who insists on adhering to a catch-as-catch-can diet.

We have no infallible panacea to offer. As a matter of fact, few full-grown problems readily lend themselves to mastication when engulfed at one bite. The gradual attrition incident to a consistent nibbling about the edges is generally more effective in the long run. It appears to us, however, that Dr. Glenn Frank[1] has recently made a suggestion which is worthy of serious consideration in that it points the way to the elimination of certain contributory and aggravating circumstances. After discussing the desirability of teaching, wherever possible, by situations rather than by subjects he asks: "But can we not, even aside from an elaborate scheme of teaching by 'situations,' provide ways and means for carrying on greater interstate commerce of mind across the academic frontiers that separate our departments?"

In this reference to the present departmentalizing of knowledge we believe that Dr. Frank has placed his finger upon one of the acute cen-

[1] "The Revolt against Education," an address delivered at Harvard University on March 20, 1926. *Sch. and Soc.*, **23**, 729–41 (1926). Cf. THIS JOURNAL, **3**, 950–3 (1926).

ters of the disorder. The average teacher has come to feel it incumbent upon him to confine himself, in the class-room at least, within the narrowest limits of his particular specialty. Too often he considers any recommendation that he abandon this attitude either as an unjust request that he assume duties which others are paid to perform or as an indiscreet suggestion that he commit the social indelicacy of meddling with matters that are none of his concern.

The former idea is, of course, unworthy of discussion; the latter is demonstrably mistaken. The older theories of the disciplinary values of instruction, upon which many of us had based a considerable portion of our educational thinking, have suffered cruel damage at the hands of the experimental psychologists. True, some ray of hope is left us in the admission that, within certain limits, transfer of learning is possible, *provided the pupil recognizes the possibility of transfer*. If we are to seize upon this remaining hope, an effort to acquaint pupils with possibilities of transfer and with means of recognizing such possibilities is clearly indicated. Obviously that effort entails the abandonment of isolationary tactics.

But the benefits which may reasonably be expected to arise from an effort on the part of the teacher to more effectively articulate his particular subject with the remainder of the curriculum include a great deal more than can be properly classified with that rather limited group of happy phenomena known as "transfers of learning." Chief among them is that rather indefinable quality which we sometimes vaguely designate as "breadth of vision." Perhaps not wholly distinct from this, but worthy of separate mention, is the greater retention of knowledge which arises from an increased number of associations.

Dr. Frank suggests that it may sometime become the function of certain departments in our universities, say, those of philosophy, literature, and history, to "accept special responsibility for helping students to see knowledge steadily and to see it whole." Probably these departments are preëminently fitted to undertake that responsibility by virtue of their mental attitude for they have always considered the sum-total of human experience as legitimately within their scope. Yet we contend that this work calls for universal coöperation and that, while one department may find its opportunities more numerous than those of another, each should consider itself responsible equally with the others.

All this, perhaps, has somewhat the flavor of a proposed educational reform which may or may not become an actuality at some indefinite time in the future. "What," one may properly ask, "has this to do with the course which I shall undertake to teach this fall?" We have spoken largely and in terms of departments, yet the principles urged are equally applicable to the everyday work of the individual teacher

and may be employed by him regardless of officially accepted theories. No doubt some revision of mental attitude is necessary on the part of many of us. Let us begin by admitting to ourselves that scientific training, however essential it may be, does not constitute the whole of education. Let us even strain a point and admit that other phases of learning may be rightly looked upon as having independent and equal importance with the sciences rather than as subordinate and supplementary to scientific training. In short, let us subscribe to a new declaration which shall hold it to be self-evident that all men are created human beings rather than scientists, brokers, or what-not and that they have an inalienable right to a well-rounded outlook on life, which right may be later abridged but is not revoked by the incidental necessity of specialized activity.

Having thus fore-armed ourselves against extremes let us seek out all the reasonable points of contact between our subject and those of our colleagues in other fields and proceed to do a little correlating of our own.

Perhaps such generalities are too vague to be genuinely suggestive. To particularize, we may begin with the English department. Frequent former editorial dissertations on this theme may have already suggested a tendency toward monomania. Nevertheless, we accept that risk by reiterating that the teacher of chemistry should, in common with other teachers, combat the apparently all-too-prevalent student notion that English composition is an end in itself, utterly irrelevant to scientific reports, examination papers, class-room recitations and to business or personal letters.

Furthermore it is both possible and proper to impress upon students the fact that courses in mathematics and physics are something more than out-grown mental exercises.

Nor do these things require the vast amount of time that some people would have us believe. A comment here and a few words there, interwoven in the course of a lecture or a recitation may illuminate many dark corners. For instance, how long does it take to point out that the method of increments, originally an expedient convention of the mathematician, begins in the light of present physical and chemical theories to have actual significance? Yet who shall say that the student's outlook is not enlarged thereby?

The student may be given practice in the use of his foreign languages and at the same time impressed with their usefulness if he is required to look up and report original articles in the literature. His interest in such exercises will be all the keener if the paper assigned to him bears the name of some distinguished figure in chemical history.

But these are scarcely new departures. At the risk of being accused of radical and visionary tendencies we venture to suggest more novel

innovations. We submit that the teacher should invite rather than evade opportunities for touching upon the historical, economic, philosophical, and even the poetical aspects of the topics which he presents.

In any course in chemistry we should find occasion to comment upon the material universe as a self-compensating mechanism. In this connection would these few lines from Marcus Arelius be too irrelevant for quotation?

> ——Do not proceed to ask, "Why was the universe burdened with creations such as these?"
>
> A scientist would laugh thee to scorn, much as would a carpenter or a shoemaker, wert thou to take them to task for the shavings and scraps of leather visible in the workshop. Yet carpenter and cobbler could throw their refuse elsewhere, if they so chose. But universal nature has no place external to herself. Nay, here lies the marvellous part of her workmanship that though she has circumscribed herself within these limits, she is able, if aught within them seems corruptible, old, and useless, to transmute it into herself, and make therefrom new creations; so that she needs neither substance from without, nor space to dispose of the decadent, but can rest content with her own place, her own material, and her own handicraft.

This naturally leads to a consideration of the manner in which the chemist, pupil of nature, is already beginning to outdo his teacher in the matter of utilizing waste and by-product material. If the course permitted a detailed survey of waste and by-product utilization one might even dig into his *Les Miserables* and present Victor Hugo's ideas on sewage reclamation for comparison with modern methods.

It is not unusual to present new subject-matter with the aid of some historical back-ground. Might it not be profitable in some cases to link this historical matter somewhat more closely with the general history of the times? The incentives which led to the development of the Solvay process, the German dye and nitrogen industries and more recently to the development of chemical industries in our own country furnish illustrations.

These are random examples, offered, not so much as suggestions for actual class-room use, as in exposition of the plan of attack recommended. We believe a reasonable and conservative application of these methods will tend not only to render scientific instruction more palatable by humanizing it but to make it more effective by relating it to other and perhaps more familiar aspects of life.

GROWTH OF THE DYESTUFFS INDUSTRY: THE APPLICATION OF SCIENCE TO ART

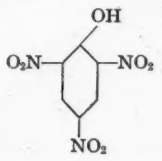
R. E. ROSE, E. I. DU PONT DE NEMOURS & CO., INC., WILMINGTON, DELAWARE

To review the growth of that branch of the chemical industry which has for its purpose the manufacture of dyestuffs and to connect this history with that of the parallel growth of our knowledge of organic chemistry is to trace the relationship of science and art in one of the most complicated fields of applied chemistry.

The interplay of cause and effect, the interchange of stimulus between academic and commercial discoveries, the comparatively long periods dividing the discovery of reactions and their commercial application, the lack of a discriminating historical record of this development, all make such an attempt hazardous but, nevertheless, there is no chapter in all knowledge which emphasizes more perfectly how science and art grow side by side, each fostered by the other.

The First Synthetic Dyestuffs

Indigo, one of the oldest of all dyes, carries the distinction of being the starting point from which was made the first synthetic dye. In 1771 Woulfe obtained a yellow dyestuff from indigo by the action of



Picric Acid

strong nitric acid. This product, the formation of which was purely an accidental find, was called picric acid because of its extreme bitterness. Curiously, it was the first color made from coal tar. It was a yellow dye for silk and wool. In 1834 another yellow or spirit soluble dye, aurine, was made by Runge from phenol. Neither of these dyes had any particular value except to show that it was possible to produce purely artificial products possessing tinctorial properties which made them worth considering.

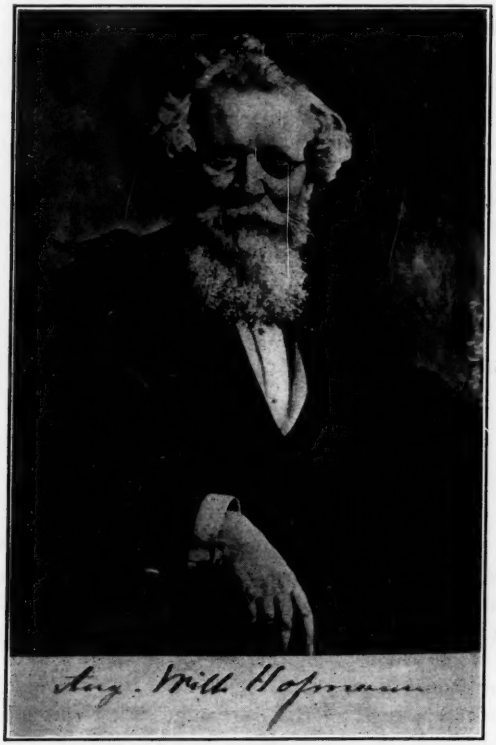
Hofmann's Discovery of the Primary, Secondary, and Tertiary Amines

It is probable that progress would have been very slow had it depended only on the commercial importance of these two discoveries. What happened next was a direct outcome of the profound studies carried out in the research laboratory by A. W. Hofmann. In 1856, at a time when nothing was known of benzene rings and the type theory was in full possession of the field, Hofmann undertook an investigation of those

types produced by the substitution of organic radicals in ammonia. His

$$R{-}NH_2, \quad \begin{matrix} R \\ R \end{matrix}\!\!>\!NH, \quad \begin{matrix} R \\ R \\ R \end{matrix}\!\!>\!N$$

researches on the subject are classics. He learned to discriminate between primary, secondary, and tertiary organic bases and showed clearly that



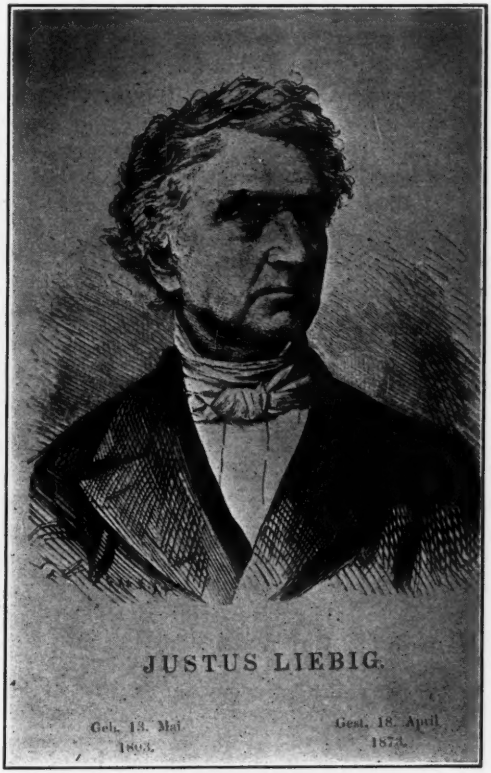
aniline, discovered by Runge in 1834, as well as the natural alkaloids might all be regarded as belonging to this class.

Perkin's Mauve

Hofmann was a great teacher as well as a great scientist, a rare but invaluable combination, and he was able to fire the imagination of all his students, among whom was William Perkin. Perkin started on a research for himself and took as his premise this argument: Quinine is a basic substance, aniline is also a basic substance. Aniline, however, since

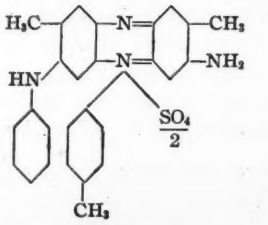
it can be made from nitrobenzene by Bechamp's reaction, is a commercially available substance. These two bases differ, as analysis shows, to the extent that quinine contains oxygen, aniline does not. If then aniline can be oxidized it may possibly pass over into quinine.

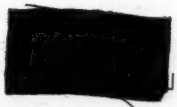
Note that this argument would have been impossible had it not been



for the development of a method for the analysis of organic compounds by Liebig in 1830.

Perkin, being young, was enthusiastic and willing to take chances (perhaps he was not aware that he was doing so). He procured some aniline and treated it with potassium bichromate. The solution became highly colored. His curiosity caused him to isolate the colored body, his ingenuity led him to try it as a dye and his business instinct told him that his discovery was of commercial importance. Actually he had synthesized the first of all the basic colors, the dye which he christened "mauve."





Mauve

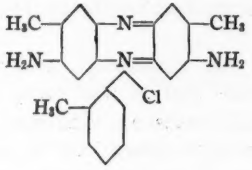
It is easy to understand why this discovery produced quite a different result from that of picric acid and aurine. Here was a vivid shade unlike any previously obtained and yet very striking. It was made from products possessing no color whatsoever and yet available enough although the aniline was quite expensive at that time. If one dye could be made, why not others? It is astonishing how suddenly an academic research led to the development of a feverish commercial exploitation. The formula indicates that the different parts of it come from the combination of aniline and toluidine and, therefore, if Perkin had had pure aniline his experiment would have failed.

Discovery of Illuminating Gas

But in addition remember that this development would have been of no importance had it not been for the introduction of illuminating gas which caused the first recovery of coal tar. Not only had coal tar been isolated but as a matter of pure scientific interest it had been separated into some of its components, among them benzene. This had been converted into nitrobenzene and into aniline, all in the laboratory, so that the ground work for the new industry was all ready. Before that, aniline was made from indigo by distillation, and was a very rare material. It owes its name to the fact that indigo is called "anil" by the Arabs.

Safranine T Supersedes Mauve

From the very start other discoveries were made in quick succession and the advance resembled nothing so much as a gold rush. In France,



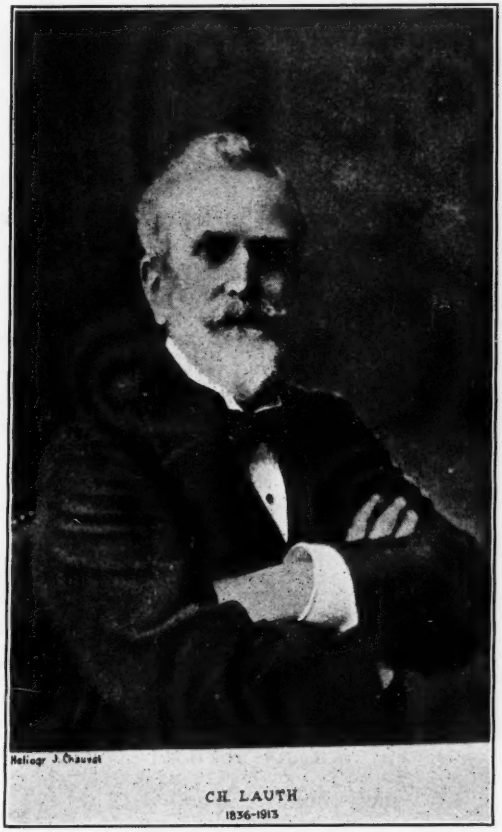
Safranine T

in Germany, in England the working became feverish and the rewards were quite remarkable. In 1859 Safranine T, a vivid pink, was placed

on the market. This superseded mauve entirely and was so good a color that it is still manufactured in very large quantities.

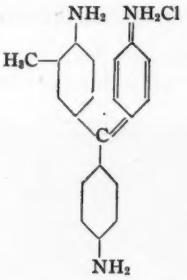
The First Triphenylmethane Dye

Sometimes the chemist has luck but never has he had such luck as in the early days of the dyestuff industry. Perkin obtained his color by



the oxidation with chromic acid of aniline and toluidine, aromatic amines. Obviously it might be expected that other oxidizing agents would cause variations in the nature of the product. Actually there are not so many reactions in which this is the case but with aniline containing toluidine it so happens that a milder oxidizing agent alters the nature of the resultant compound entirely and thus it was that Verguin in 1859, using stannic

chloride, converted this mixture into a blue red dye which was christened "magenta" in honor of the great victory of the Italians.

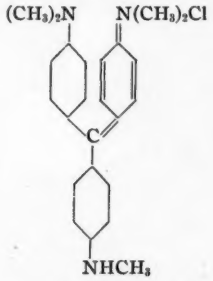


Magenta

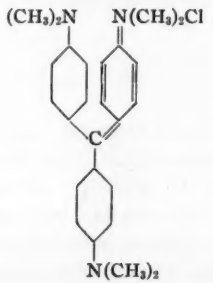
In this case the three benzene rings are held together by a carbon atom and therefore magenta was the first of the true triphenylmethane dyestuffs.

The Triphenylmethane Basic Dyes

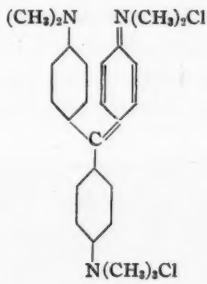
The luck still held because the triphenylmethane group, unlike the safranine group, is one in which a great many different compounds can be made easily and these compounds vary materially from each other in color. Magenta has three amino groups in it. The hydrogen of these can be substituted by alkyl groups. The penta-methylated compound



Methyl Violet

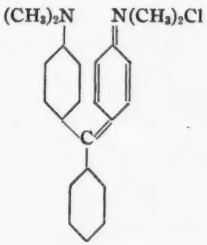


Crystal Violet



Methyl Green

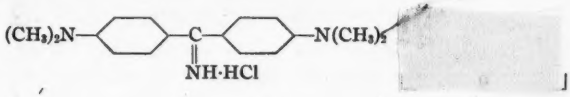
which was discovered by Lauth in 1861 is methyl violet and the hexa-methylated is crystal violet, a greener shade. The benzyl-penta-methyl derivative is a very blue violet. A green can be made by adding methyl chloride; methyl green. In 1877 it was found possible to make a color in which one of the amino groups was absent altogether; Malachite green.



Malachite Green

Auramine, a Diphenylmethane Dye

This very fine series of dyes lacked a yellow entirely, but in 1883 a true basic yellow was discovered, Auramine.



Auramine

Early Use of Synthetic Dyes

All of these new products were extremely brilliant. They were, however, all fugitive to light but that did not matter so much because they were used on silk, being very expensive, and no one thought much then of putting such bright colors on cotton.

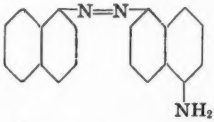
From the chemist's point of view they are all, without exception, salt-forming bases and the dyer still knows them collectively as basic colors.

Aromatic Amines

The next great strike in the dyestuff field came seventeen years after Perkin's discovery. A series of isolated finds led up to it. In 1856, as we have said, Bechamp's method for reducing organic nitro bodies placed aniline

$$\text{Aryl—NO}_2 \xrightarrow{(\text{Fe} + \text{HCl})} \text{Aryl—NH}_2$$

and its homologs as well as naphthylamine and some diamines at the disposal of the organic chemist. In Hofmann's laboratory Perkin and Church experimented with a number of these bases before Perkin was drawn away by his discovery of mauve. Hofmann had already shown that nitrous acid has a very characteristic effect on alkyl amines and it was natural for Perkin and Church to try this reagent on the aromatic amines. Using naphthylamine they produced a compound which at first they thought would make a good dye but which was in reality quite useless. (Notice how Perkin was on the lookout for dyes.) It was a violet only in the presence of hydrochloric acid and turned to a dull orange on the fiber when washed. Perkin tried several ways of converting this color body which we now know as amino-azo-naphthalene, into a better dyestuff but failed.



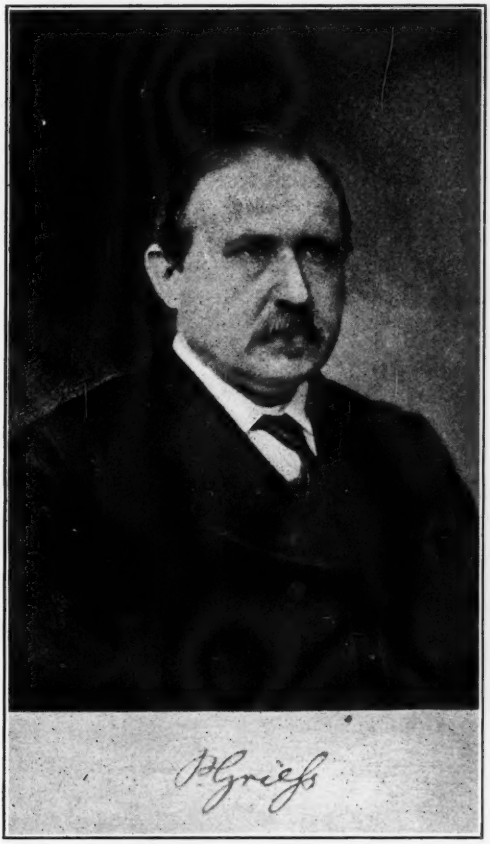
Amino-azo-naphthalene

The first practical discovery resulting from the action of nitrous acid on aromatic amines was the making of a yellow from aniline which was of no value itself as a dye on textiles because it was insoluble in anything but spirit, but which proved an excellent starting point for the manufacture of members of the safranine group of colors.

The Azo Reaction

It was necessary for the science to develop before progress could be resumed and the scientific pioneer who carried forward the work was Peter Griess. Peter Griess was one of those geniuses who manage to do more in their leisure hours than most men accomplish in all their working days. In 1866 he began a series of experiments on the behavior of aromatic amines in the presence of nitrous acid, *i. e.*, the fundamental investigation of the casual results which had been obtained by Perkin and others. Fortunately Griess was an astonishingly clever experimenter because the compounds he made are among the hardest to handle in the whole realm of organic chemistry. Here was a man who, for the love of his science and in his spare time, he being a chemist in a brewery during his working day, developed one of the most fundamental of all synthetic

methods. Let me remind you, who may be rather far from your organic chemistry, of the nature of this great reaction. In an acid medium nitrous acid attacks an aromatic amino group in such a way that the two hydrogen atoms are displaced and one nitrogen atom is added, together with the acid radical, which may be present. The product formed is



one we call a diazonium compound. These bodies are active beyond anything else with which we deal except, perhaps, hydrofluoric acid and

$$\text{Aryl—NH}_2 + \text{HONO} + \text{HCl} \longrightarrow \text{Aryl—N(=N)—Cl} + 2\text{H}_2\text{O}$$

their versatility is infinitely greater. When dry they are terrifically explosive; in solution they undergo rapid decomposition especially on

warming, giving rise to phenols. When brought into contact with naphthols, phenols, or amines, they condense to form new complexes for which the general formulas are

(1) $\text{Aryl—N(=N)—Cl} + \text{H}_2\text{N—Aryl} \longrightarrow \text{Aryl—N=N—NH—Aryl}$

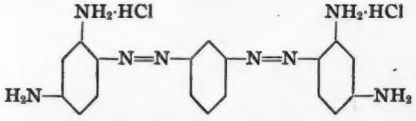
(2) $\text{Aryl—N(=N)—Cl} + \text{Aryl—OH} \longrightarrow \text{Aryl—N=N—C}_6\text{H}_4\text{—OH}$

(3) $\text{Aryl—N(=N)—Cl} + \text{C}_6\text{H}_4\text{—N(CH}_3\text{)}_2 \longrightarrow \text{Aryl—N=N—C}_6\text{H}_4\text{—N(CH}_3\text{)}_2.$

Diazotization and coupling are the basic reactions of all the azo dyestuffs, which are made in enormous quantities by the very methods employed by Griess.

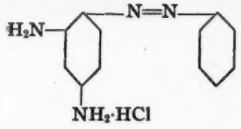
The First Azo Color

The first real azo color was made in 1865 when nitrous acid was allowed to act on meta-phenylene-diamine. It was called Manchester Brown.



Manchester Brown

The further development of this field came only when other organic substances were made available. In 1876, William, Thomas, and Dower put on the market a color made by Witt who was then working in their employ. This was a very bright orange-brown which was called chrysoidine. It was a really good basic color and caused quite a sensation. Its producers did not patent it because they did not believe that any one



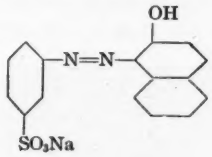
Chrysoidine

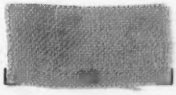
could find out what it was. However, in a very short time a paper appeared over the name of A. W. Hofmann in which it was shown that the new color was made by adding diazotized aniline to meta-phenylene-diamine.

The First Acid Azo Dyes

In November, 1876, the firm of Poirrier in St. Denis put out a set of orange colors which were very brilliant and different from the artificial

colors which had been made previously in that they were sulfonic acids, that is, the colored part of the molecule itself was acid and not basic as in the case of the aniline colors. These very excellent acid colors caused a great deal of excitement. Orange II is still very largely used.



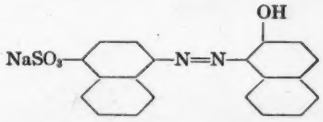


Orange II

It is made from sulfanilic acid and beta naphthol. Note that the chemical advance was in converting aniline or other aromatic bases into sulfonic acids which are water-soluble.

Substituting Artificial for Natural Colors of the Same Shade

The year 1878 saw the introduction of a very good acid azo red, Fast

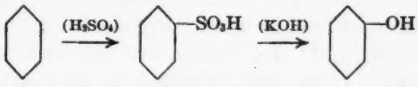


Fast Red A

Red A. It was then that the real struggle between natural and artificial colors began. The only conflict between the two types of colors before, was in 1869 when artificial alizarine took the place of the natural product with which it was chemically identical. This new development was the substitution of azo colors differing entirely in structure from natural colors of the same shade.

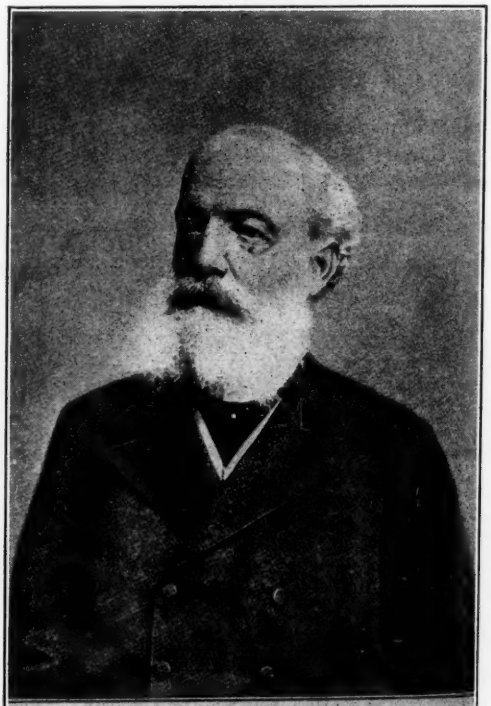
The Work of the Pure Scientist

Let me emphasize the part played by the pure scientist in this advance. The fundamental reaction was that of Griess, the explanation of the reaction was that given by Kekulé who, by his introduction of the mechanical working model, the benzene ring, and of a similar model for naphthalene made it possible for chemists to understand what they were doing. In addition Kekulé, by his work on sulfonation and the conversion of sulfonic acids into phenols by fusion with potassium hydroxide,



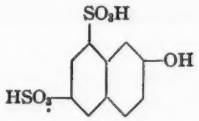
made available essential intermediates. Moreover, in this direction also, Hofmann stimulated the work by a brilliant scientific description

of Orange II. In this paper he showed how it was made and how innumerable were the variations possible in making similar dyes. In addition it was in this paper that Hofmann called attention to the fact that Griess' reaction was by no means restricted to unsubstituted amines but could be used in the case of amino sulfonic acids. Sulfonic acids of naphthalene soon became the rage in the industry and then disulfonic

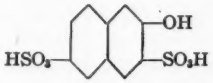


AUGUST KEKULE VON STRADONITZ.

acids. If they were naphthol sulfonic acids they were brought into reaction with the diazotized amine, if they were amino sulfonic acids they could themselves be diazotized and coupled with anything that would couple, or diazotized amines could be coupled with them. In the course of this violent turning over of the field, two disulfonic acids were made from beta naphthol. These two differed from each other simply in the position of the two sulfonic acid groups. They differed sufficiently to allow of their fairly ready separation and the two isomers were used in a



G Acid

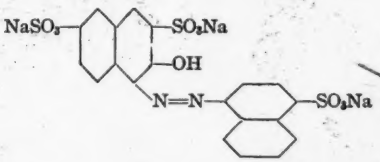


R Acid

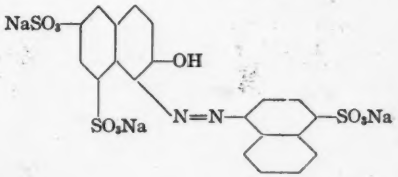
series of dyestuffs each member of which consisted of the same base coupled to the two different disulfonic acids.

The Effect of Isomers on Color

It was with surprise that the dye chemist discovered that the position of the sulfonic acid groups which he considered as having no color value, actually made a great deal of difference in the hue of the dyestuff which was made. In this case the one isomer gives more orange shades



Amaranth (bluer)

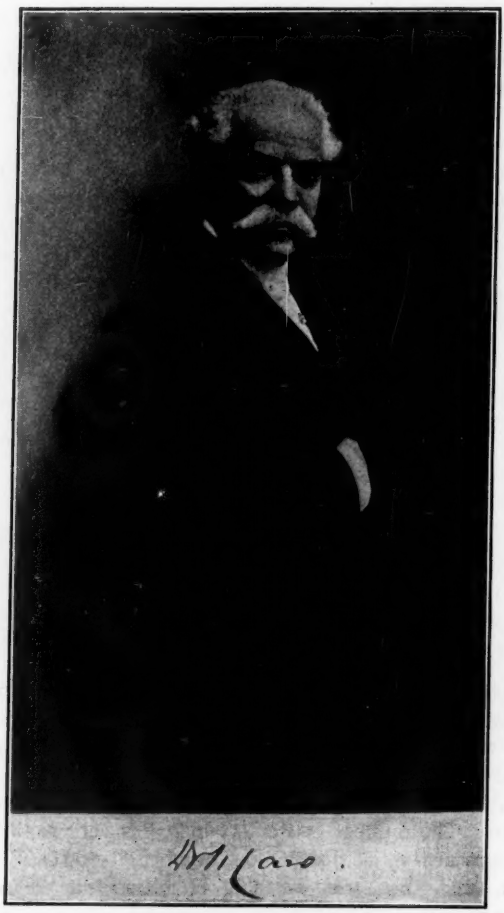


Cochenille Red A (yellower)

of red, the other bluer shades. In this series a red equal to natural cochineal was discovered. The recognition of the fact that isomerism had so much to do with color heightened the chemist's understanding of the number of possibilities because, in the case of naphthalene, a di-substitution product, if the substituents are dissimilar, can exist in 14 forms, if they are similar in 10. The number of isomers increases very rapidly and for 8 different substituents the possibilities number 10,700,000. Every kind of a sulfonic acid, then, was worth investigating but the nature of the work was very special and called for an understanding of the theories of organic chemistry. It is to the credit of the directors of the dyestuff industry that they realized at once that they could only progress if they interested real chemists in working for them.

In Germany, in particular, every dye house employed all the research men that it could get hold of. Because of this intense research, naph-

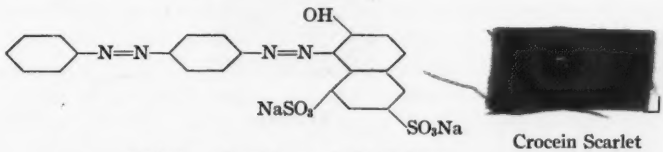
thalene yielded all sorts of products. If any one of these products showed useful characteristics as a dye component, efforts were made to produce it on a plant scale, a problem often much harder than that of isolating the compound in the laboratory. The existence of isomers had other



consequences. It was not always possible to produce only one isomer in a plant reaction, therefore, it became necessary to find some means of using up the one which was not particularly wanted. Sometimes this meant making new intermediates to go with the less desirable isomers.

The Diazo Colors

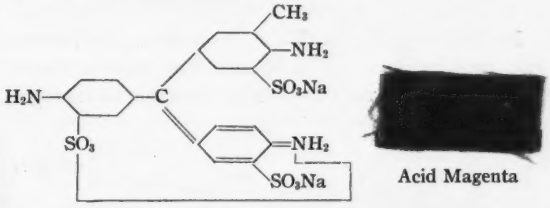
Further advances were made after a paper published by a disciple of Griess described the diazotization of amino azo bodies and their coupling. As a first fruit of this discovery the dye chemists made crocein scarlet, still one of the brightest scarlets in the whole line.



Crocein Scarlet

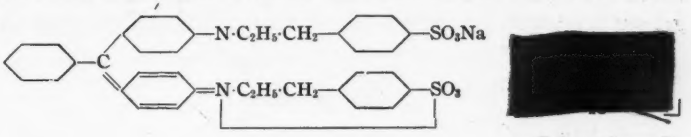
Triphenylmethane Acid Colors

In the group of sulfonated azo colors all were oranges and reds, just as the colors of the basic series were blues, violets, and greens. The dyer always wants a complete line which will work in the same way so that he can blend his colors. The fact that the azo group contained no blues stimulated interest in converting the basic colors into water-soluble acid colors by sulfonation. It was in this way that good blues and violets were produced for use with the azo colors on wool. Thus the acid colors of the triphenylmethane series became quite important. Acid magenta in 1877 was the simplest type of this series, being produced by direct



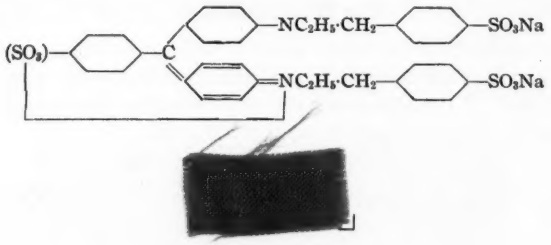
Acid Magenta

sulfonation of magenta. In 1883 we find a group of colors in which the sulfonation is in the substituent attached to the nitrogen; thus Guinea Green B contains two benzene groups which are sulfonated. Light Green

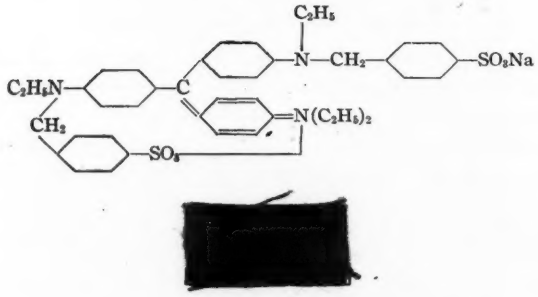


Guinea Green B

SF Yellowish was introduced in 1889. This differs from Guinea Green B in being sulfonated also in the third phenyl group. Acid violets made from methyl-benzyl-aniline and para-di-alkyl-amino-benzaldehyde were introduced.

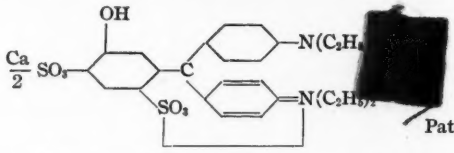


Light Green SF
Yellowish



Formyl Violet S4B

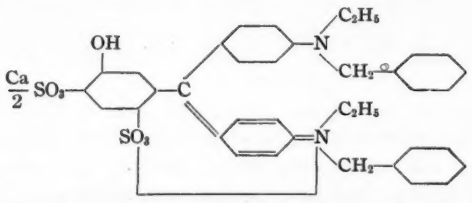
In 1888 the firm of Meister, Lucius, and Brüning put on the market two very valuable green blues. The first of these, Patent Blue V, has the structure shown. It is faster to light than indigo carmine which is pro-



21

Patent Blue V

duced by sulfonating indigo and has the great advantage that it appears greener in artificial light which prevents the dulling which so often occurs in



22

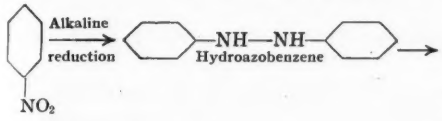
Patent Blue A

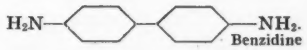
mixtures containing a blue component that goes red. The "A" brand is very

nearly the same except for the fact that two benzyl groups replace two of the ethyl groups in the "V" type. The difference between the two brands from the dyer's point of view is that the one is faster to fulling than the other.

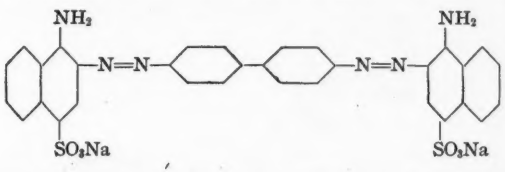
The Direct Cotton Colors

All the artificial colors mentioned so far are useful only on silk and wool or on cotton which has been mordanted. In 1884 Boettiger discovered that benzidine, a compound produced by a peculiar reaction from nitrobenzene, was an extraordinarily valuable intermediate for azo colors. The benzidine reaction had been thoroughly investigated by the academicians Zinin, Hofmann, and Fittig. It represents a very interesting





rearrangement in the molecule. This base, on treatment with nitrous acid, is tetrazotized, that is, it is diazotized at both ends of the molecule and it will then couple with two molecules of a naphthol or an amino naphthalene sulfonic acid. Boettiger made the discovery that the presence of the benzidine nucleus in an azo color confers upon the dye the property of coloring cotton directly from a neutral or slightly alkaline bath. He coupled tetrazotized benzidine with naphthionic acid and obtained an intense red—Congo Red—and this was the first of the direct colors to be rec-



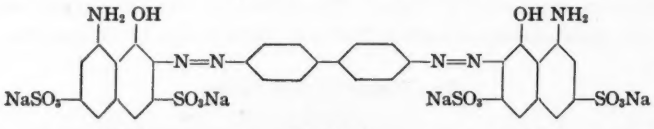
Congo Red

ognized, although another benzidine dyestuff had been made previously which on testing was found capable of dyeing cotton directly.

Varying the Shade

The history of the blues in this series is interesting as showing how the dye chemist was able to give the dyer what he wanted, even though it involved some very complicated work. The first blue ever made was produced in 1885 by coupling toluidine with 1-4 oxy acid. This was no good. In 1890 one was introduced which was made from benzidine and H acid. Notice that H acid is by no means a simple molecule. This

blue, which is called Direct Blue BB, is very red and dull. It is still



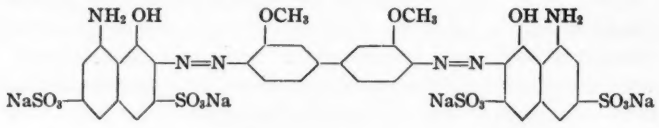
(H acid) (Benzidine) (H acid)

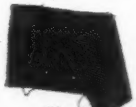
24

Direct Blue BB

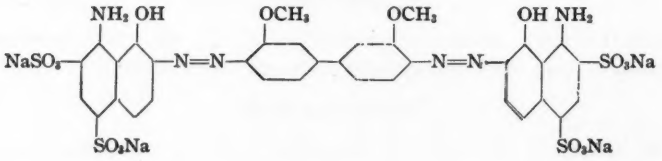
made in enormous quantities because it is very cheap and is good enough for a great many purposes.

Griess had discovered that ether-substituents in the molecule tended to make azo colors bluer. Dianisidine was then made and coupled with H acid. This gave a very much brighter and greener blue than the blue BB. Finally, in 1896, it was found possible to increase the brightness by using Chicago acid in the place of H acid, Chicago acid differing from H acid in the position of the two sulfonic acid groups. The resultant color is very distinctly greener and brighter.





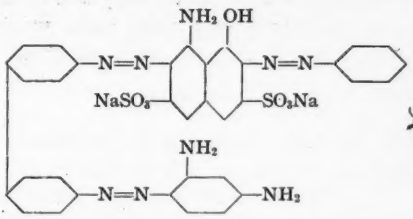
Sky Blue 5B



Sky Blue 6B

Developing Colors with Specific Properties

Once the range of azo colors covered all the necessary hues, the effort of the manufacturers was turned toward producing fastness and a great deal was done and is still being done in this direction. The relation of constitution to fastness is a very interesting chapter. Here, it must suffice to state that we know certain fundamental rules which express

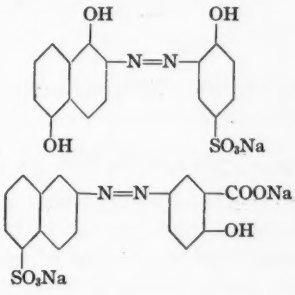


Direct Black E

the relation of the component parts to the properties of dyestuffs. The complexity of the molecules handled can be emphasized by the formula of Direct Black E which is the azo dye made in larger quantities than any other and sold at a very low price.

Azo Chrome Colors

In addition to producing beautiful acid colors for wool and silk and direct colors for cotton, the dyestuff chemist was able to produce azo colors which reacted with chromium hydroxide on the fiber to form very stable chrome colors. These chrome colors became increasingly important and nowadays practically all very fast colors on wool for men's suitings and overcoats are dyed with chrome azo colors of such types as



Chrome Black PV

Chrome Yellow

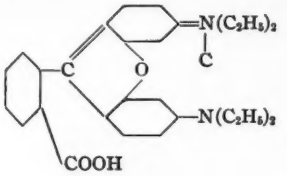
Chrome Black PV and Chrome Yellow to cite two examples. Actually then the artificial azo colors have displaced the old chrome alizarin derivatives.

After the making of the azo colors it is very difficult to follow a chronological order. The industry was obviously surprisingly successful and

even in 1880 a number of different paths were being developed. The science was a new one, it attracted a very great many chemists, some of them of outstanding genius. The whole field was very alluring. The puzzles of isomerism appealed to that instinct of the human intellect that finds pleasure in solving puzzles providing there is some small chance of success and some means of demonstrating the accuracy of the solution reached. We find, then, that both in the industry and in the laboratories of the great universities discoveries were being made which affected the course of events in the dyestuff industry quite materially.

Xanthone Colors

Adolph von Baeyer was also interested in the organic chemistry of dyestuffs. As we shall see, it was he who elucidated the puzzle of the structure of indigo. In 1871 he carried out some purely academic work on the interaction of phthalic anhydride and phenols. In this way he discovered fluorescein which is a thin yellow and of no value as a dyestuff but astonishing in fluorescence. Starting from this, Caro made eosine in 1874, a most beautiful though highly fugitive dyestuff. In 1875 erythrosine came on the market but the real development of this group dates after 1887 when it was discovered that it was possible to make phthalein dyes from substituted amino phenols and phthalic anhydride. Rhodamine B, is an extraordinarily strong blue-red of a very characteristic shade.



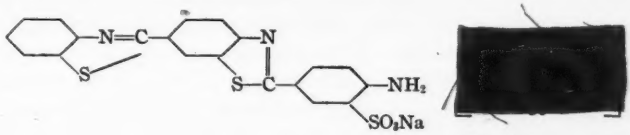
Rhodamine B

Rhodamine 6G is much yellower. The structure of these two compounds is analogous to that of fluorescein.

Benzanyl Dyes and the First Ice Color

It is surprising how often we find the young man making successful additions to our knowledge of dyes. In 1877 Arthur Green, then a very young chemist, discovered that the action of sulfur on ortho-toluidine gave rise to a pale yellow product insoluble in water. This on sulfonation gave a direct dye of the same shade, a substance of no particular value in itself but one which contains an amino group and therefore capable of undergoing Griess' reaction. When primuline was treated with nitrous acid and coupled with beta naphthol a very brilliant red was produced.

Di-hydro-thio-toluidine, when it is oxidized by hypochlorites, gives a

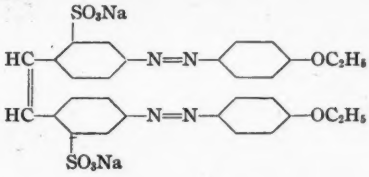


Primuline, developed

very valuable fast yellow, Chloramine Yellow. The constitution of this dye is not clear. The activity in this group was very brief but it yielded several dyes which are still used. Research began in 1887 and was all finished by 1892. Since then there have been no additions to the line.

Stilbene Colors

Another group of colors of very great importance in the development of which Green was instrumental, though they were not his discovery, was that consisting of dyestuffs obtained by the action of alkaline reducing agents on para-nitro-toluene-sulfonic acid. The interaction gives rise to sulfonated derivatives of stilbene, containing azo groups. These stilbene yellows are very much used as paper dyestuffs and for other purposes and in the same series is a color which is not usually spoken of as a stilbene yellow and yet has a similar structure—chrysophenine, the most important direct yellow.

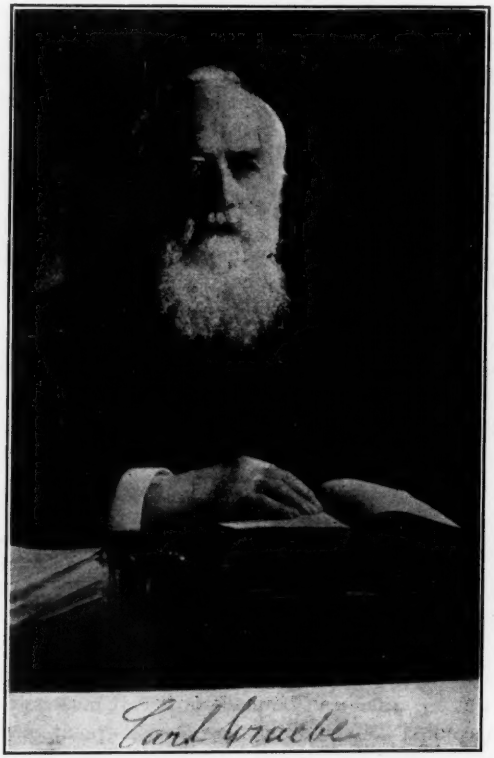


Chrysophenine

Sulfur Colors

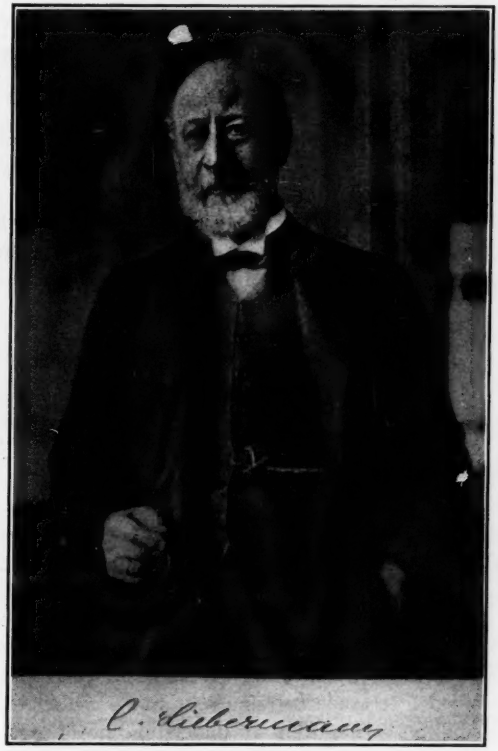
It is quite obvious that the ultimate success of a dyestuff is a result of the practical use which can be made of it. It matters not at all how interesting a colored body is from the chemist's point of view nor how brilliant it is, if it does not allow of successful application, and successful application means a great deal more than the layman thinks. In thinking of a dye it is natural to visualize something very bright, a really vivid hue, but actually the great bulk of dyed materials used are dull because it is not altogether pleasant to have in our surroundings too much color unmodified by black. As a matter of fact, enormous quantities of cotton are dyed either black or in neutral shades such as khaki. For this purpose great purity of hue is not at all essential. What is wanted are good working qualities in the dye house and good resistance to the rough usage which cotton must undergo, in addition to low cost, because cotton is a cheap

fiber. Sulfur colors are enormously successful simply because they fulfil these conditions. Unfortunately the dyestuffs of this class lend themselves very poorly to the purpose of tracing the advance of theory and art. It so happens that they are all made by reactions which leave us in doubt as to the nature of the end product. This was typical of the very first one which was produced in 1873, because this was made by



taking all kinds of vegetable matter such as sawdust or shavings and other similar materials and heating these with sodium sulfide to a temperature between 100° and 350°C. The resultant product dyed cotton from a bath containing sodium sulfide to a dull brown shade. Little more was done in this line until, in 1893, the possibilities of such methods of synthesis were again made evident by Vidal who made a good black by treating amino phenol with sodium polysulfide. This dye, Vidal Black, which curiously enough was put out by Poirrier Company, who, as we have seen, were the first to introduce acid azo colors, caused quite a

sensation because it was fast to washing, light, and acids, at least in comparison with the direct colors, because in 1893 the first of the good direct blacks, Columbia Black FF, was not on the market. Now Vidal had already made a fairly good brown from acetyl-para-phenylene-diamine by a similar reaction and, therefore, there seemed to be a possibility of filling out the line with other shades. Very active research commenced



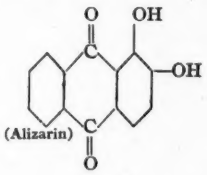
in this new field, haphazard since it consisted of taking every conceivable kind of material and fusing with sodium sulfide or sodium polysulfide. While the method was crude the results were excellent and in a very short time a wide range of sulfur colors made their appearance. The name of the class is derived from the fact that all these dyes are insoluble in water but are converted into water-soluble products by the action of sodium sulfide. In addition they are all made by the use of sodium sulfide so that the name is very natural.

The greatest triumph in the field was that of Priebs and Kaltwasser

who, in 1899, discovered that 1.2.4. di-nitro-phenol gave a beautiful black. This is still, in point of quantity, the most important of all dyes with the exception of indigo. It is very cheap, it is a simple color to make and apply, and it is a real black. Its composition is unknown. By 1905 the field was practically abandoned but by then it contained a great number of good browns, yellows, and olives, and also blues, which were good enough to compete with indigo provided no fastness to bleach was required. In spite of this fact the colors which were discovered are used to a very large extent and are among the most important of all synthetic dyestuffs.

Alizarin

To emphasize the point once again, organic chemistry and the manufacture of dyes always grew together and as new methods for the control of organic reactions and a better understanding of the nature of the products of these reactions became prevalent, new advances in the dye-making art always followed. Turkey red was always considered the finest of all dyes, being extraordinarily fast and a beautiful clear shade.

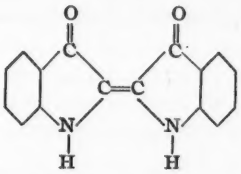


Turkey Red

It had only one drawback and that was the difficulty of applying it. Naturally, the organic chemist turned his attention to this admirable dyestuff. With the help of Kekulé's generalizations and by the invention of special methods of procedure, Liebermann and Graebe in 1868 were able to show that alizarin had the following formula, Turkey red being the color produced when alizarin is applied on an aluminum mordant. By 1869 the color was made synthetically from anthracene and the madder fields were doomed. It would be difficult to find a clearer example of the industrial possibilities arising from an understanding of organic products.

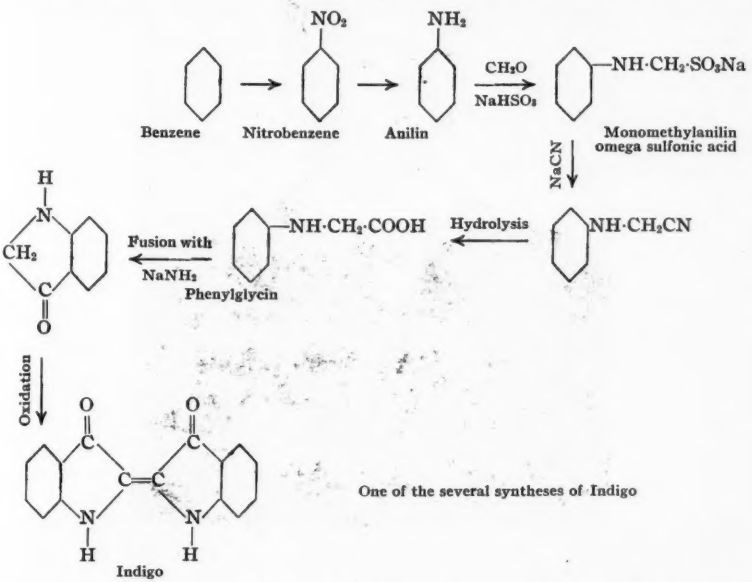
The Synthesis of Indigo

Indigo parallels Turkey red in interest but when the organic chemist endeavored to clear up the structure of this dyestuff he found it a very much harder task than in the case of alizarin. Actually Baeyer devoted twenty years to the study of indigo before its constitution was thoroughly established. Once that was known it was easy to write down a series of formulas on paper which would allow of a synthesis of indigo. However, these were hopeless in the plant either because of too great a cost or because the yields were impossibly low. Baeyer completed his work in 1884 but it



Indigo

was only in 1894 that artificial indigo came on the market and that was due to the discovery of just the right condensing agent to use in converting phenyl glycine into indoxyl, the indoxyl passing by oxidation directly into indigo. Instead of caustic, sodium amide, made by passing am-



One of the several syntheses of Indigo

monia over sodium, was used. This one improvement made the difference between commercial failure and a brilliant success.

Alizarin Derivatives

Having learned his power in other fields the organic chemist felt that he wanted to do something to alizarin by modifying the molecule and thereby producing new dyestuffs. As a matter of fact progress was slow. The anthracene group is not an easy field in the chemist's sense and beyond doing a few very obvious and simple things such as treating alizarin with nitric acid and with sulfuric acid, very little was done that resulted in any success at all. It was found possible to add maroons and garnets

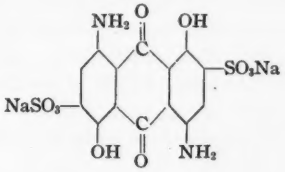
similar to alizarin but all applied in the same way and there was even a good blue in the line which was made by a very complicated reaction. Advance was considered very doubtful until two men of very high attainments devoted themselves to the chemistry of this group of dyes. Réné Bohn, an Alsatian who studied in Switzerland, and Robert E. Schmidt,

who happened to be of exactly the same birth, are the two men who did most for this very important class of colors. Bohn went as a young chemist to the Badische Anilin and Sodafabrik. His countryman went to the rival house of Friederich Bayer in Elberfeld. The men were friends. They entered exactly the same field of research and both of them in their work exhibited an astonishing ability. They were not only great chemists but they were also great practical men in the sense of understanding how

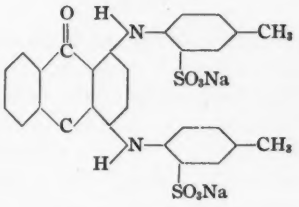
dyestuffs should be employed. The story of the struggle of these two men to outdo each other for the sake of their firms is an extremely interesting one. Both were recognized by their employers as being men of the very first rank, even while they were yet very young. In consequence they were both allowed to have all the assistance they thought necessary and were given unlimited support in their work.

The Acid Alizarin and Chrome Anthracene Colors

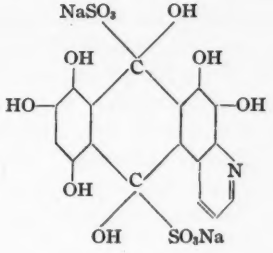
The chemistry of the alizarin compounds is so complicated that it would not be advantageous to give the details of the advance made by these men, but Bohn's resourcefulness can be illustrated by pointing out that he found, for instance, new methods for introducing hydroxyl groups

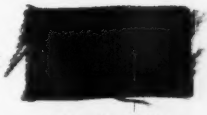


Alizarin Saphirol B (Schmidt)

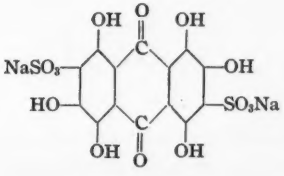


Alizarin Cyanin Green G





Alizarin Indigo Blue S (Bohn)

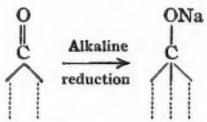


Anthracene Blue SWX (Bohn)

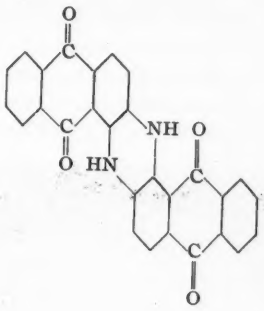
into alizarin and thereby produced some very beautiful blues. Schmidt did very much the same thing but also found methods for making acid dyestuffs of this series, products so excellent that they are still in active demand although relatively very expensive. If you will look through the anthracene colors listed in those very useful works, the dyestuffs tables of Schultz and of the Society of Dyers and Colorists, you will find in the column devoted to the name of the inventor that Bohn and Schmidt appear over and over again against the very colors which are of the greatest value. Beginning with low-temperature oxidations in air (quite a new method in this field) Bohn introduced such reactions as the use of sulfur and fuming sulfuric acid in order to effect reduction previous to sulfonation. Schmidt found the great value of adding boric acid to sulfonations in the alizarin series. It is actually a fact that the work of these two men was so remarkably successful that the old alizarin dyes which were dyed with a chrome mordant became pretty nearly extinct, being substituted by the newer colors which could be used very much more easily. Organic chemists will find a great deal of interest in looking up the obituary notice of Réné Bohn in the *Berichte* of the German Chemical Society.

The Vat Dyes

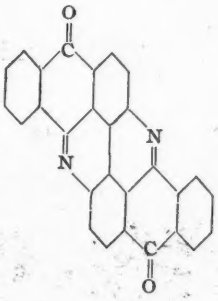
After having modified alizarin colors and improved the series of chrome colors immensely, Bohn's attention was caught very naturally by the great progress which had been made in the synthesis of indigo and it occurred to him that it ought to be possible to make an anthracene derivative corresponding to indigo. For this purpose he took beta-amino anthraquinone and fused it with potash. The product which he obtained seemed at first quite useless but he found that if he treated it with a reducing substance as was done in the case of indigo he could get dyeings of a blue shade which were very remarkably resistant. He named his new product Indanthrene from indigo and anthracene. The best way to follow his advance from this point is to show the formulas of the products which he obtained. All of these dyes contain a CO group and they are also, of course, derivatives of anthracene. The negative nature of the anthracene makes the ketone group, when it is reduced to the OH group, slightly acidic, and therefore these extremely insoluble bodies will dissolve



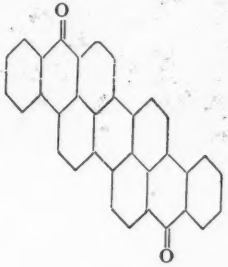
in caustic soda in the presence of a strong reducing agent such as sodium hydrosulfite. This solution or vat is usually quite different in color from



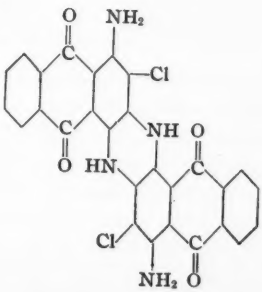
Indanthrene Blue R



Indanthrene Yellow G

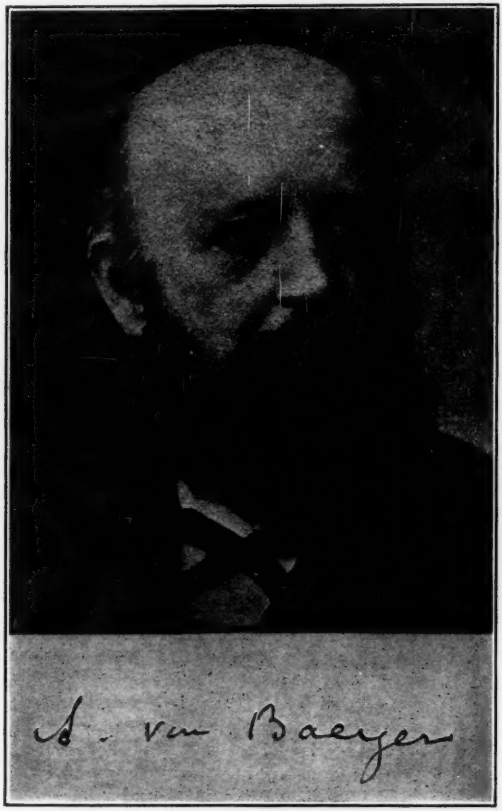


Indanthrene Violet R



Indanthrene Green BB

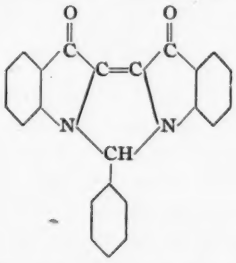
the original dyestuff and from the shade that results finally on the fiber. The vatted color on the fiber oxidizes spontaneously in the air and produces a highly colored substance, extremely inert chemically, deposited practically in the fiber. The vats of these colors are so sensitive that Bohn had to do a great deal of work in establishing the best formula for applying them



and he also had to do a great deal of encouraging in order to get the dyers interested at all. Nowadays the vat dyestuffs of this series rank as the very finest dyes in existence although not all of them are equally fast. They are brilliant, they are easy to apply if precisely the right conditions are maintained, and they last longer than the fiber upon which they are deposited. The chemistry of this group has been carried much further in the laboratories of the manufacturers of dyes than it has in those of institutions of learning.

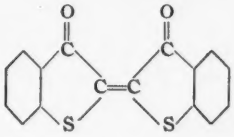
The Indigoid Vat Dye

The indigo molecule was attacked just as had been the alizarin molecule in order to turn it into color derivatives. By the action of bromine a brighter indigo which dyed much greener shades was obtained but on the whole there was not much success in modifying indigo except that in 1883



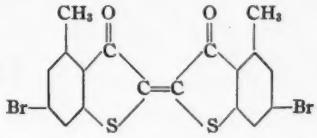
Indigo Yellow 3G

Indigo Yellow 3G, which was a condensation product with benzoyl chloride, was introduced. This was the first indigo derivative of a hue different from that of the parent substance. The research laboratory of the university made the next advance. In 1905 Friedlander found that he could make a sulfur analog of indigo which was a dull bluish red. Its formula is:

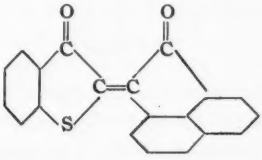


Thioindigo Red B

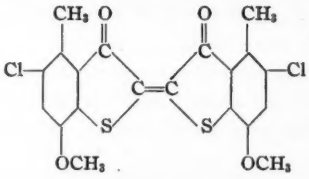
This was the first of the thioindigo dyes and very soon a great many more made their appearance. They are all vat colors; they reduce more easily than those of the anthraquinone series but they are not so fast on the whole.



Helindone Pink BN



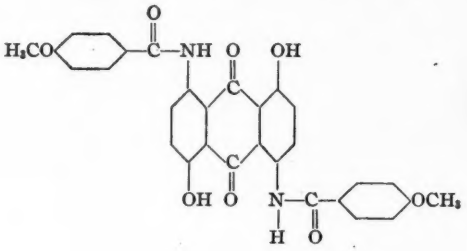
Thioindigo Scarlet 2G



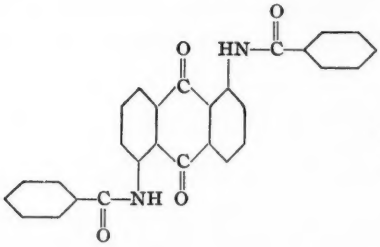
Thioindigo Violet 2B

Algol Dyes

There is another group of colors in the vat series, also anthracene derivatives. These are the Algol colors introduced by the Bayer Company to compete with the Indanthrene colors of the Badische Company. The story goes that a number of these dyes had been made long before but that no one had found any way of using them and they were all on the shelf. When Bohn introduced his method of dyeing vat colors, these bottles were taken down and it was found that among them were a number of good vat dyestuffs; which brings home the lesson that one must be more than merely a chemist to succeed in the making of dyes.



Algol Brilliant Violet R



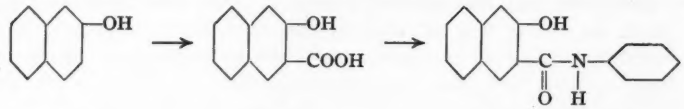
Algol Yellow R

Ice Colors

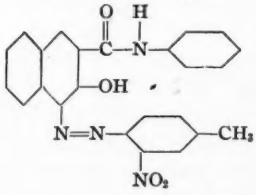
In general it is true that fastness to washing is related to insolubility. The sulfur colors and the vat colors are fast because they are precipitated in a water-insoluble form on the fiber. The direct colors are not so fast because all of them are by definition water soluble and go onto the fiber

to a certain extent, especially in the presence of salt, but will dissolve off again if treated with hot water and especially with soap. The azo colors with their very great range of shade would be much more valuable if they could be used in some way that would leave them in an extremely insoluble form on the fiber. The chemist's first attack on this problem was to synthesize the dyestuff on the fiber from soluble components using molecules that had no acid groups in them and therefore would not wash out. The first advance in this field came very early when beta naphthol dissolved in caustic was used to impregnate cotton and was then coupled with diazotized paranitraniline. A bright red is produced on the fiber which is faster to washing than the ordinary direct color. However, para red is not by any means an ideal dye because, on account of its low molecular weight, it sublimes off the fiber when subjected to heat. Also it is not fast to light. Again, from the dyer's point of view, there is the objection that the beta naphthol is not a dyestuff and does not have any "affinity" for the fiber. Therefore, the whole process is one of impregnation and the chance formation of the dyestuff on the cotton which necessitates drying after impregnation and before developing. However, para red was enough to show the chemist that there might be a possibility of making azo colors that were fast to washing and resembled Turkey red. Primuline, as we have already seen, was a step in the same direction but it is nothing like as fast to washing as Turkey red and it is very fugitive to light. The only advantage it shows over para red is that the first component has a real affinity for the fiber and that makes it much easier to handle, from the dyer's point of view. What was needed was a molecule possessing affinity for cotton which could be coupled with a diazotized base to give a red of the shade of alizarin, together with fastness to washing, fastness to light, and fastness to bleach. It seemed utterly out of the question to hope for anything like this because the azo colors as a class are not fast to bleach and they are not extremely fast to light. However, the chemist persevered and the solution of the problem came in 1912. In order to increase the affinity of the first component for the fiber it was necessary to use something less soluble than beta naphthol. In order to leave the hue red it was necessary not to complicate the molecule too much. Now solubility, generally speaking, is in inverse proportion to the size of the molecule but an increase in molecular complexity changes the hue usually from red to blue. Therefore, it was necessary to reconcile two incompatibilities. This problem was solved in the following way. First beta naphthol was converted into beta-hydroxy-naphthoic acid using Kolbe's salicylic acid method. This alone was no improvement. Then the carboxylic acid was converted into the phenyl amide by condensing with aniline in the presence of phosphorus oxychloride. In this way

the anilide of beta hydroxy naphthoic acid was produced which is less soluble and more colloidal than beta naphthol and therefore has affinity for the fiber. However, the addition to the molecule is so far from the naphthalene nucleus that it does not change the hue from red. When this compound is developed on the fiber with diazotized meta nitro para toluidine a very vivid red is produced which is fast to light, chlorine, and



Beta naphthol | Beta hydroxy naphthoic acid | Anilid of beta hydroxy naphthoic acid



Naphthol AS Red

washing and is, therefore, comparable to alizarin red. At the same time it is much easier to apply. This very brilliant solution of an extremely difficult problem has led to active development in this field and now the range of ice colors, as they are called because it is necessary to use low temperatures in the diazotization and coupling, extends all the way from a very fast yellow to black.

This short account does not do justice to the great story of the development of the chemistry of dyestuffs and its application to human needs. It does not do justice to the perseverance, the endurance, the brilliance of those who advanced this realm of industry. One fact should stand out and that is that the growth of this industry, resting on profound chemical knowledge, has been more stimulated by the rare genius of those who create, either in theory or in practice, than by any other factor. It is true that success, as in every industry, has come of good management, good fortune, wise financial development, and business foresight, but, nevertheless, it is equally true that the great advances which have measured the financial success of dyestuff corporations have actually been based on the efforts of those who created new knowledge. Perhaps it will be clear, from what has been said, that the secret of the creator is to spare no effort in gaining a profound, an intimate knowledge of his subject, though frequently this may mean a waste of money and time utterly at variance with good business practice. Actually it is true that an investment in fundamental knowledge is intangible but at the same time

it is the most important investment of all in the field of dyestuffs and in every other.

The days of the pioneers are never over in scientific development and there is the same call for genius now that there was when the dyestuff business was in its infancy. The world always needs those who create.

"Toxamins," Opposite of Vitamins, Discovered in Oatmeal and Bread. Vitamins, the group of beneficial though little-known substances found in certain foods, have a family of evil-doing opposites, according to Prof. Edward Mellanby, F.R.S., of Sheffield University. These malignant twins of the vitamins he has christened "toxamins," and he claims that they exist in greatest concentration in the foods that are used as the principal elements of diet by large sections of the white race. The most notable offenders in harboring his newly discovered causes of ill-health, he says, are oatmeal and wheat. The principal effects of the presence of toxamin so far investigated are prevention of proper bone formation, and in some cases serious nervous disorders.

The harmful effects of oatmeal and other cereals on the development of bone can be reduced if the cereals are allowed to germinate for some days and are then heated at boiling temperature for eighteen hours. Both germination and heat are necessary for this purpose, it is stated.

The scientific reason for spreading butter on our bread is that apparently the harmful effect of the toxamins in cereals is counteracted by the fat-soluble vitamins, which are present in the butter.

The troubles which vitamins act to prevent and cure have long been regarded as being due merely to a lack of the proper vitamins in the diet, so that these diseases, such as rickets and beri-beri, have come to be known to physiologists as "deficiency diseases." If Prof. Mellanby's claims are confirmed by later investigation, an entirely new aspect will be placed on this whole series of ailments, since their causes will be transferred from a merely negative category to a group of really positive evils. Many physiologists and physicians are still doubtful of the genuineness of the new discoveries and the subject is one that is likely to be much controverted for a time.—*Science Service*

Oxidized Copper Surface to Aid Battery Charging. A simple oxidized surface of copper may replace vacuum tubes, acid solutions, or mechanical vibrators in new current rectifiers, which change alternating into direct current for charging storage batteries and operating radio sets, if a new discovery of L. O. Grondahl, New York engineer, comes into wide use.

By subjecting a piece of metallic copper to a high temperature, a coating of oxide of copper forms on its surface, and Mr. Grondahl has found that such an oxide layer has the property of allowing an electric current to pass through it in one direction only. If an alternating current, which flows first in one direction and then in another, changing faster than a hundred times a second, is passed through such a device, it is changed into a current which pulsates, but only flows in one direction.

In practice Mr. Grondahl uses a copper disc one and a half inches in diameter, against which is firmly pressed a piece of lead, in contact with the oxide coating. As a piece of copper of such a size has a very low resistance, large currents may be carried, and as the oxide film does not wear out the rectifier unit never needs to be replaced.—*Science Service*

SOME PHASES OF THE WORK OF THE BUREAU OF CHEMISTRY ON DUST EXPLOSIONS IN INDUSTRIAL PLANTS*

DAVID J. PRICE, BUREAU OF CHEMISTRY, WASHINGTON, D. C.

Extent of the Problem

It can be generally accepted that practically all types of combustible dusts when mixed with air in proper proportions form an explosive mixture which can be readily ignited by various external sources.[1] This being recognized, it is found from a survey of a recent census of the manufacturing establishments of the United States that over 28,000 plants, employing approximately 1,324,422 persons and manufacturing products with a value exceeding $10,000,000,000 (10 billions) annually, are subject to the dust explosion hazard.

The Bureau of Chemistry has obtained records of 281 explosions of this character in industrial plants in the United States and Canada. In 70 of these explosions 459 persons were killed and in 92 of them 771 persons were injured. In 144 explosions the property loss was approximately $33,529,350, an average of nearly $240,000 for each explosion.

Nature of Research Investigations

The research investigations, in the Bureau of Chemistry, of industrial plant dust explosions and fires relate to the following:

(*a*) Explosions in grain handling and milling plants, such as grain elevators, flour mills, feed grinding plants.

(*b*) Explosions in grain threshing machines (confined principally to the Pacific Northwest and similar dry territories).

(*c*) Fires in cotton gins and explosions and fires in cottonseed meal and cotton oil mills.

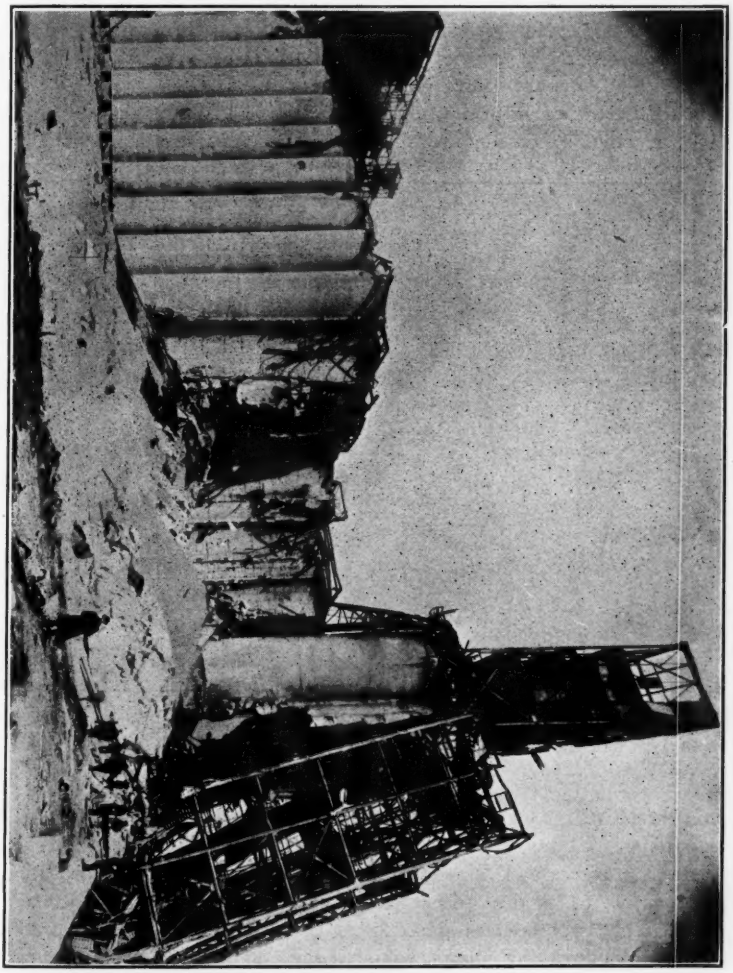
This work in the Bureau of Chemistry is a development from the work in the Bureau of Mines, where all work relating to coal dust explosions is carried on, and had its origin in connection with the coal dust explosion studies in that bureau.

The investigations in the Bureau of Chemistry are confined principally to dust explosions in milling and grain handling operations. The knowledge acquired on this subject has therefore been obtained largely in dealing with this phase of the problem. Very little work has been done in the industries outside of what would ordinarily be called the "grain industries." It is apparent, however, in view of the wide range of industries affected, that the work should be extended to these newer types of plants. For example, we now recognize certain dust explosion hazards in some of the chemical industries. Before we can advance far enough

* Address delivered at meeting of Association of Chemistry Teachers of D. C., Central High School, Washington, D. C., April 16, 1926.

[1] Price and Brown, "Dust Explosions," Natl. Fire Prot. Assoc., Boston, Mass., 1922.

to develop any effective control measures, it will be necessary to determine the processes in which these hazards exist and the circumstances under which an explosion can originate.



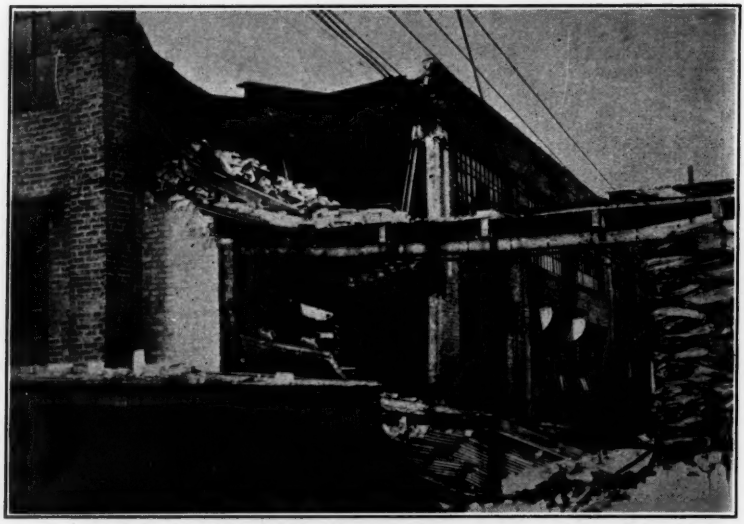
Results of an explosion of grain dust in the world's largest grain elevator located at South Chicago, Ill. Six men were killed, with approximately $4,500,000 property damage.

A Review of Some Early Dust Explosions

Although in recent years large losses of life and property have occurred from dust explosions and resulting fires, we find from the data available that explosions of this character in the United States are on record as

early as 1860.[2] According to notes of the Turin Academy of Sciences, it has been assumed that the first flour dust explosion recognized as such happened in Italy, December 14, 1785.[3] Faraday refers to the possibility of explosions of coal dust in his lecture in the Royal Institution on January 17, 1845. An explosion in the Stettin Roller Mills in Germany in 1858 was discussed at the sessions of the Polytechnic Society in Berlin on December 22nd of that year.[4]

With the exception of a wood dust explosion in Detroit in November, 1874, in which 11 persons were injured, and an explosion of starch dust



Results of an explosion of hard rubber dust in a Michigan plant in which 8 men were killed, one other injured, and property damaged to the extent of about $25,000.

in a New York confectionery plant in 1877 with a property loss of $120,000, apparently all the dust explosions on record in the United States and Canada previous to 1880 occurred in flour mills, with a combined life loss of 18, injury to 3 and a property loss which probably exceeded $1,000,000.

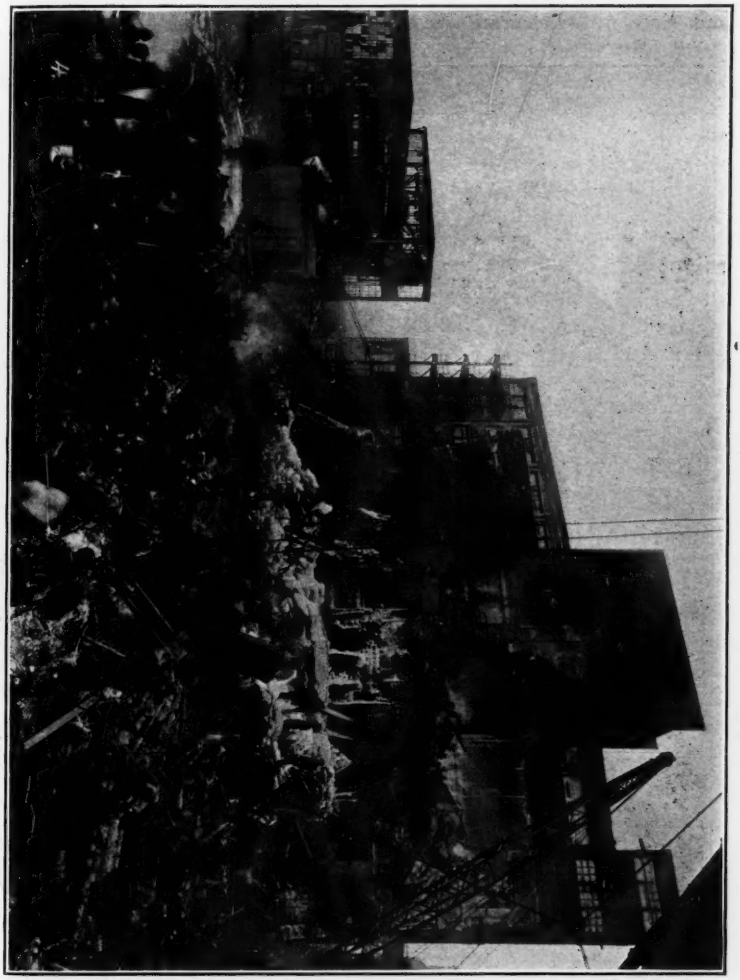
Between 1880 and 1890 dust explosions occurred in breweries and malt houses, woodworking plants, confectionery plants, a fur cleaning plant, and flour mills. From 1890 to 1900 explosions took place in sugar re-

[2] *J. Am. Ins.*, **2**, No. 4, 7, 8, 26, 1925.

[3] *Am. Miller*, **17**, 20 (1889).

[4] Dr. Ing. Paul Beyersdorfer, "Straub-Explosionen," Theodor Steinkopff, Dresden and Leipzig, 1925.

fineries, a soapine plant, lumber mills, and flour mills. The first explosion in a grain elevator occurred in this period, causing the loss of 10 lives and injuries to five persons. From 1900 to 1910 there was a large increase



Results of an explosion of starch dust in which 42 men were killed, 20 injured and plant badly damaged.

in the number of dust explosions, owing, no doubt, to the increase in the number of manufacturing plants. Special attention was given during this period to coal dust explosions in mines. Explosions were reported in a number of new lines of industry, such as starch factories, cork handling

plants, cotton mills, and fertilizer plants. A number of explosions occurred in woodworking plants and malt houses.

During the period 1910 to 1920 the Bureau of Chemistry of the Department of Agriculture began a scientific study of grain dust explosions, and since 1914 accurate records have been available. Although 14

In this explosion of pulverized sugar dust in an Eastern refinery 12 men were killed, 24 injured, and a large quantity of sugar destroyed by the fire following the explosion.

explosions in flour mills were reported during this ten-year period, no lives were lost in this industry from dust explosions, only three men were injured, and the property loss was low in comparison with that in other industries. It is now generally believed that the reduction in the explosion and fire losses in flour mills during this period can be attributed directly to the installation of dust control equipment. On the other hand, thirty explosions were reported to have occurred in grain elevators, with a loss of 34 lives and injury to 47 employees. In three of these explosions the property loss exceeded $1,500,000, with a total loss in the 30 explosions reported of more than $7,500,000. The losses in feed and cereal mills for this period were also very heavy, with 58 employees killed, 122 injured, and a property loss in the 17 explosions reported of more than $3,600,000.

The losses from dust explosions and resulting fires for the ten-year period 1910 to 1920 showed the urgent need of developing methods for preventing such losses. The total losses—194 killed, 332 injured, and property damage of more than $19,000,000—far exceeded those of any previous period. In this period explosions occurred in an aluminum manufacturing plant, a celluloid manufacturing plant, chocolate manufacturing plants, oilcloth factories, cork plants, cotton mills, fertilizer plants, a powdered milk factory, paper mills, phonograph factories, a rubber reclaiming plant, shoddy mills, spice mills, sulfur-grinding plants and tanneries.

The records for 1920 to 1925, comprising the first half of the ten-year period, indicate that the number of plants in which the explosion hazard exists is constantly increasing and that new methods of manufacture, with the necessary types of mechanical equipment, have created additional hazards. Since 1920, explosions of wood dust, flour, zinc dust, powdered rubber, sugar, aluminum dust, ground spice, sulfur dust, magnesium powder, cork dust, powdered milk, paper dust, dye material, pitch dust, leather dust, lignone, and starch have occurred. Extensive losses occurred in the starch plants and in grain elevators.

Similarity to Gas Explosions

Dust explosions appear to be similar to gas explosions. The various dusts have definite ignition temperatures the same as the flammable gases. The burning temperature of the dust, however, is somewhat lower than the temperature required for propagation of flame. According to Dixon and Coward,[5] the ignition temperatures of certain of the gases in air have been determined as follows:

Carbon monoxide	644–658°C.
Hydrogen	580–590°C.

[5] *Trans. Chem. Soc.*, **95**, 514–43 (1909).

Ethylene	542–547°C.
Methane	650–750°C.
Ethane	520–630°C.

The ignition temperatures of the following five typical dusts and also the temperatures necessary for the propagation of flame were determined by Wheeler:[6]

	Ignition temperature	Propagation temperature
Dextrine	540°C.	940°C.
Sugar	540°C.	805°C.
Starch	640°C.	960–1035°C.
Flour	650°C.	1060°C.
Grain	630°C.	995–1050°C.

It will be observed that the ignition or burning temperature of dextrine and sugar (540°C.) is comparable to that of hydrogen (580°C.) and that of ethane (520°C.). The burning temperature of starch, flour, and grain dusts is about the same as the ignition temperature for methane, 650°C. It will be seen, however, that, although the ignition temperature of dextrine and sugar is 540°C., from 805 to 940 degrees' temperature is required before the flame will propagate and spread through the dust cloud. In the case of starch, flour, and grain dusts the ignition temperature, approximately 640°, must be increased to grades ranging from 960° to 1060° before flame propagation occurs.

Rate of Flame Propagation

Different experimenters have determined the velocities of propagation of flame in gaseous mixtures and have given the following results:[7]

	Velocity per second	
	Meters	Feet
2 parts hydrogen + 1 part oxygen	2820	9250
4 parts coal gas + 5 parts oxygen	2700	8876
1 part ethylene + 3 parts oxygen	2364	7724
1 part methane + 2 parts oxygen	2322	7616
2 parts carbon monoxide + 1 part oxygen	1680	5510

Under different conditions and with different dusts, the Bureau of Mines and the British and French Experiment Stations have measured velocities of from 2000 to 3300 feet per second, while in certain tests there have been indications of velocities considerably higher than these, in fact of over 6000 feet per second.

Pressures

In large-scale tests with coal dusts, pressures as high as 270 pounds per square inch have been obtained. No such accurate tests have been

[6] *Chem. & Met. Engr.*, **24**, 29–33 (1921).

[7] Price and Brown, "Dust Explosions," *loc. cit.*, p. 5.

made with flammable dusts other than coal dust. A few tests have been made with flour and starch in the large-scale testing gallery of the Bureau of Mines. The conditions, however, were such that results could not be considered accurate. From these tests, however, it would be reasonable to expect that pressures of at least 300 to 400 pounds per square inch might be developed in explosions of these materials.

Limits of Concentration

The dusts apparently have lower and higher limits of concentration similar to the explosive gases. The lower limit of concentration of methane, CH_4, has been given as approximately 5.5%, with the greatest pressure produced when the mixture of 9.6% is obtained and the degree of explosibility decreasing when the percentage reaches 14.5. In work with seven type dusts, namely, starch, grain elevator, wheat elevator, sulfur, sugar, aluminum, and coal, it was found that pressure could be developed upon the ignition of a mixture of 7 ounces of starch per thousand cubic feet of air (0.007 oz. per cu. ft.).[8] This was also true in the case of sulfur and aluminum, but ranged from 10 to 17 ounces per thousand cubic feet (0.010 to 0.017 oz. per cu. ft.) with the elevator and coal dusts. This would indicate that an ignition of the starch dust cloud could be obtained with a lower limit of concentration of 0.007 ounce per cubic foot.

Ignition Sources

The ignition sources of the dusts are apparently the same as for gases, and a readily accepted theory would be to conclude that any source of ignition which will cause an explosion of gas will correspondingly cause an explosion of dust.

Degree of Fineness

It is evident that the degree of fineness is a contributing factor to the explosibility of these different industrial dusts. It has been generally felt that the finer the dust cloud, the more readily it could be ignited and the more rapid the rate of flame propagation. However, from recent work by Bouton of the Bureau of Mines with two typical coal dusts, the following conclusion is reached: "Flammability does not increase indefinitely with fineness, but seems to reach a maximum and then fall off or at least remain constant as the fineness is still further increased."[9] Whether this theory applies to dusts other than coal remains to be determined by further experimental work. The results obtained by Bouton were based on tests with Pittsburgh and Pocahontas coals.

[8] L. J. Trostel and H. W. Freuert, *Chem. & Met. Engr.*, **30**, 141–6 (1924).

[9] Bouton and Hayner, "Rate of Combustion of Coal Dust Particles," *Bull.* **22**, *Carnegie Inst. Tech.*

Progress in Knowledge

Since the study of dust explosions was undertaken considerable knowledge has been acquired on the subject. Our ideas have changed, however, since the origin of this work. For instance, it was at first thought that before a dust explosion could take place it was necessary to grind or crush the grain and extract the starchy or powdery material from the interior of the kernel. Until the explosions began to occur in grain elevators it was not fully realized that the dust created by the attrition of the grain itself was explosive.

It is now generally agreed, however, that practically all types of these combustible dusts are explosive and about the only dusts that can be considered immune from explosions are the inert dusts such as shale and limestone.

This development in the field of dust explosion research has extended to many fields outside of the grain-handling industry, and indicates the importance of a study of the hazard existing in practically every line of industry.

Change in Industrial Attitude

In the early stages of this work in the Bureau of Chemistry, it was necessary to devote considerable time to an educational campaign to acquaint both the operators and the employees in industrial plants with the hazard of dust explosions. At that time very little knowledge was available as to the circumstances under which these explosions occurred, their nature, and behavior. Until this educational work had reached an advanced stage it was customary for some of the industries where dust explosions had not occurred to feel that they were not subject to this hazard. This was based entirely on operating experience.

In recent years, however, the attitude of operators of industrial plants has changed markedly. It is no longer customary to wait until a dust explosion actually takes place to demonstrate the hazard. Many industrial companies are now endeavoring to determine the possibility of a hazard of this character by obtaining from the Bureau of Chemistry assistance in testing the dusts created during manufacturing operations. If it is found that the dust is of an explosive nature, steps are taken immediately to obtain further coöperation and assistance in the development of control measures.

Stages of Explosion

There are usually two stages in a dust explosion—the primary and the secondary explosion. The primary explosion is usually a minor ignition with local effect, but accompanied by sufficient concussion and pressure to shake into suspension any dust settled on beams, ledges, and other inaccessible places throughout the plant.

This matter of dust control is vitally important and suggests the need of efficient mechanical equipment for the effective removal of both suspended and static dust. If precautions are taken to guard against the ignition of dust and the plant is well maintained and good housekeeping is practiced, the explosion hazard is considerably reduced.

Control Measures

In dealing with the control problem it is necessary to study fully the operating practices in individual industries. Control measures must be developed for each specific industry, because many plants require specialized mechanical methods and equipment in their operation. There are, however, some processes which are common to many lines of industry, and a control measure which has proved effective in one type of plant may have general application to a number of lines. For instance, the hazard in grinding and pulverizing operations is common to many industries. The Bureau of Chemistry has endeavored to overcome this hazard by developing the use of inert gases for the prevention of flame propagation during the grinding of materials in which explosive dusts are created.

Inert Gas Development

Early experimental work by the Bureau of Chemistry showed that an explosion of grain dust cannot be initiated in a gas mixture containing 12 per cent or less of oxygen, the remainder being inert gases.[10] An operating unit of this character, installed at Arlington, is being used by the Bureau of Chemistry for demonstration purposes. The boiler flue gases afford a cheap source of carbon dioxide and are introduced directly into the grinding equipment. Very satisfactory results have been obtained and the Bureau feels that there is a wide application for this control method.

Character of Investigations

The investigations of dust explosions comprise both engineering and chemical studies. The engineering investigations relate to the determination of the causes of the explosions occurring in various types of industries and the development of control or preventive measures. The chemical investigations are confined primarily to the determination of the ignition temperatures of the various dusts, the oxygen dilution necessary to prevent explosion, the pressures produced, the limits of concentration, sources of ignition, and other data essential for the determination of the relative flammability of these industrial plant dusts.

[10] *Ind. Eng. Chem.*, 9, 347 (1917).

THE RELATION OF CHEMISTRY TO THE ENRICHMENT OF LIFE*

ELIZABETH DAWSON, ARSENAL TECHNICAL SCHOOLS, INDIANAPOLIS, INDIANA

Lack of knowledge is the cause of superstition, yet superstition, by instilling wonder in the mind and heart of man, has sometimes led him to great wisdom. It was this wonder and curiosity concerning the closed book of nature which caused the more stout-hearted of the ancients to peer beneath its great covers. Since it was the gradual opening of this book that has given to us the chemistry which is of such vital importance to the enrichment of our lives, let us, that we may better grasp the full significance of this science, and its great influence on civilization, trace its progress by first imagining ourselves in ancient Egypt at the very dawn of civilization.

ELIZABETH DAWSON

We have no known facts upon which to base investigation; we have nothing with which to investigate. Consequently, we imagine, ponder, think, and as a result, are led to speculate, thus giving to the new science of chemistry its first stage of existence, speculation.

During this time of speculation, about the sixth century B.C., Thales advances his belief that water is the material from which all others have their origin. Anaximenes and Heraclitus believe air and fire to be basic elements. Then all Egypt listens with interest and some doubt to the idea of the existence of five elements, air, water, fire, earth, and the ether, propounded by the daring Aristotle and seconded by Empedocles. We are informed that the great philosopher, Buddha, is teaching a sixth, namely, consciousness.

Upon entering now the thirteenth and fourteenth centuries we find that alchemy is being practised by the Egyptians and also the Chinese, Arabians, and Greeks, who broaden new paths for investigation by connecting alchemy with philosophy. The alchemists, who prefer to call themselves philosophers, represent their science, alchemy, in the person of Hermes Trismegistus, who is the embodiment of strength and who carries the symbol of wisdom.

These philosophers believe that the changes continually taking place

* Prize-winning high-school essay, 1925–26.

in the metals of the earth are due to endowed life; that under certain conditions a perfect or noble metal may be produced, body, soul, and spirit, if only the seed might be obtained.

Then begins a long search for the "Philosopher's Stone," which is said to have the powers of giving health and wisdom, ennobling the character, heightening the faculties, raising the standards of life in general, transmuting the elements, and providing an elixir of eternal life.

After some experimentation in metallurgy comes the era when more practical ideas and discoveries of the alchemists are applied to various phases of life, for example, art. The dominance of alchemy is soon over, but from its smoldering fires spring the flames of the greater chemistry of the present day, which, it seems to me, might be defined as the art and science of living. Indeed, living is, itself, a chemical process.

I have chosen to outline, in brief fashion, the history of chemistry in Egypt because that country is one of the oldest to make practical use of chemical knowledge, scant as it was, in everyday life. Their mural designs and artistic, colorful pottery, which have survived through the centuries, are the direct result of applied chemistry. The Egyptians pursued life with the purpose of unraveling its mysteries to the advantage of humanity; they nourished the diminutive spirit of science in their undaunted pursuit of chemistry, they influenced its growth in other countries, and for their reward have gained the distinction of being one of the most highly civilized of the older nations.

Civilization, surely, is the real enrichment of life. Chemistry, possessing powers as marvelous as those of the famous old Philosopher's Stone, provides that enrichment lavishly.

Owing to the darkness which has veiled the sciences so long, the students of chemistry, by experimenting, have developed accepted scientific truths from theory; they have, in studying metals, learned to consider their relationship with the planets; they have forced themselves to what they considered the utmost limits of their mental capacities, only to find themselves capable of still more. In setting for themselves the goal of knowledge, they have raised the standards of the common people to a higher level; in using their strength of mentality unreservedly they have increased the capabilities of themselves and others with whom they have come in contact, and in inventing and discovering have nobly benefitted literature and the fine arts thereby ennobling the character of all classes of people. Thus has chemistry achieved three virtues of the famous Philosopher's Stone of the Dark Ages. The chemistry of today makes no distinctions between sovereigns and common men; it now enriches all. It has built from chaotic ruins of ignorance an orderly construction of knowledge.

Chemistry has long been applied to the study of medicine and it is

still very necessary to the physical well-being of all. Although modern chemistry is not wholly concerned with the study of medicine, that study is peculiarly dependent upon chemistry. The knowledge of chemical compounds and action and reaction is indispensable to pharmacy. Many formerly unknown disease germs have been found by the use of recently discovered coal-tar dyes, which color only certain kinds of organisms. Discovery of disease germs is very important since the cause is an aid to finding a remedy.

Chemistry, in the interest of hygiene, gives attention to antiseptics, counteracting processes, effects of temperature and air, and to the purification of bad air, of which the ancients were aware but which they were unable to control since they did not know of the presence of different gases in the air. The use of chemicals as anesthetics has saved countless lives. Chemists have made and are making many advancements in the cooking, handling, and preserving of food; they are able to detect adulterations and to determine the energy needed for the nutrition of the body.

It was the chemist, Pasteur, who, through his observation on fermentation, gave to the world the principles of pasteurization and sterilization. Chemistry, in the aid of physical humanity, has fulfilled another promise of the precious, much sought, old Philosopher's Stone, the prolonging of life.

Parallel with human life is plant life. This is also benefitted by the chemist, who, in addition to giving to the agriculturist information about the soil, its composition, process of oxidation, and prevalent microörganisms, has made it possible for him to supply, in economical plant foods and fertilizers, those elements which, by chemical analysis of the soil, have been shown to be lacking. "Putting fertilizer on the soil is similar to putting money in the bank," says Cushmann in his "Chemistry and Civilization." The chemist, from his minute observations on the processes and valuable products of plant life, has been able to duplicate many of these products in great quantities, and oftentimes to far surpass them in quality.

The study of chemistry and its application not only enriches mentality, human life, and plant life, but enables further growth of civilization by the utilization of the inorganic elements of the earth.

The chemist, in utilizing these inorganic elements, has assigned to them their various uses after carefully considering their physical and chemical properties. The part that these elements play in everyday life is astounding. For example, aluminum, the best metal ever known for making cooking utensils, he has produced from certain kinds of clay. Knowing some of its compounds to be extremely hard, he employs them in making synthetic rubies and other gems.

He knows that zinc will not rust so he uses it as a protective covering for thin sheet iron, which has valuable qualities of strength and durability but is susceptible to rust.

He knows that the noble metals, gold, silver, and platinum will not rust, so he uses them in making certain laboratory apparatus where resistance to the action of chemicals is necessary. He uses copper in alloys, potassium compounds for the manufacture of soap, fireworks, and gunpowder; he makes sodium compounds, gives us bleaching powders; calcium compounds, mortar, fertilizer, and glass; magnesium compounds, silver polish and toothpaste. He uses magnesium in photography. He knows that iron is the cheapest and most valuable of metals and he employs it in many ways.

In discussing chemistry in industry, the comparatively small but rapidly thriving coal-tar industry is worthy of mention. Coal tar, which for a long time was a waste product, has been utilized by the chemist and created into more different useful substances than there is space to name here. The most important of these, however, are the dyes which are used so extensively at present.

Chemistry has given to everybody a riot of gorgeous colors, with myriad soft shades and tints of each color. Surely these are the source of much of the pleasure and joy of life. No longer must one seek the exclusive little snail of the Mediterranean Sea to procure the rare and costly Royal Purple for the King's robe. No longer must acres and acres of valuable, fertile land be invested in the cultivation of the madder plant, in order that some little girl's cape may be red rather than white, for the chemist, by synthesis of alizarin from anthracene, is able to manufacture easily and quickly more beautiful and adaptable colors than Mother Nature ever dreamed of making.

Dyes are not the only useful properties of the generous coal tar. Saccharin, an artificial sugar many times sweeter than the "real thing," and not injurious, although lacking in food value, is derived from coal tar. Other products which owe their existence to the same humble origin are various oils, acids, explosives, and certain perfumes. Coal-tar products are used for different purposes in a great number of industries.

Chemistry, in giving us heat and cold artificially, has emphasized economy. To give an idea of the immense value of refrigeration, I shall quote from Molinari's "Treatise on Chemistry" which says that by refrigeration a certain country of Europe was able in 1900 to import 6,434,000 frozen sheep from Australia, New Zealand, and South America, 60,000 tons of frozen beef from America and Australia, 167,000,000 eggs from Morocco, Egypt, the United States, and Russia, and 65,900 tons of butter from the United States, Australia, New Zealand, and Canada.

In the United States alone over 12,000,000,000 tons of food are preserved by cold each year.

Chemistry has given us the use of such small but useful articles as matches, photographic materials, drugs, leather, rubber, paints, varnishes, glass, cement, ceramics, dyes, soaps, cosmetics, artificial silks, flavors, and soda water. The modern electric lamp, by utilization of tungsten, is a chemical triumph over the luminous gas mantle of Auer von Welsbach. Electricity may be produced by chemical means, and, on the other hand, many useful chemicals are now produced on a large scale by electricity.

Liquid air, a recent and promising discovery of chemistry, is being used in the economical preparation of oxygen, nitrogen, and explosives. The recent war has proved the necessity of chemistry to national defense, but it is equally necessary to the vast reconstruction going on. Truly, as Edwin Slosson remarks in one of his books, "The test-tube is mightier than the sword." Chemistry may, in the future, directly promote international peace by bringing the nations closer together by swifter travel, improved radio methods, or by a common understanding and application of science in general. Chemistry has given us the things, both great and small, which have contributed to the enrichment of our lives and aided our civilization.

Chemistry has offered us democratic education by means of printing and by the introduction of inexpensive wood-pulp paper. Chemistry has aided travel, communication, and entertainment. It has given us protection, economy, industry, and common sense. Stanislaus had somewhat the same idea as expressed by Thomas Henry Huxley, "Science is, I believe, nothing but trained and organized common sense, differing from the latter only as a veteran may differ from a raw recruit, and its methods differ from those of common sense only so far as the guardsman's cut and thrust may differ from the manner in which the savage wields his club." I think I may safely say that there are very few sciences in which chemistry is not at some time involved.

Chemistry is casting aside the darkness and is enjoying itself in the warm light of its own remarkable discoveries. It is not resigning itself to the comforts and pleasures of its own creation, for, not content with strengthening mentality, aiding physical life, and utilizing the elements and their compounds in the service of man, it is continuing its work of enriching life and procuring yet more knowledge. "For as the circle of light grows, the surrounding darkness expands also."[1]

Perhaps chemistry itself is the elusive Philosopher's Stone, for it has provided all but two of the virtues attributed to that stone, the transmutation of elements and the elixir of life.

[1] "Creative Chemistry," by Edwin E. Slosson.

It seems that Father Time has become addicted to that popular and quite good habit of imitating the best of people and is trying to impersonate the ancient Hermes by embodying strength. It seems that he has half a mind to discard his sickle for a staff of wisdom and strive hopefully forward with chemistry and the spirit of science seeking further enrichment of life.

UNITED STATES CIVIL-SERVICE EXAMINATION

The United States Civil-Service Commission announces open competitive examinations for Fuel Engineer, $3800; Associated Fuel Engineer, $3000; Assistant Fuel Engineer, $2400.

Applications for these positions must be on file at Washington, D. C., not later than September 7th. The examinations are to fill vacancies in the Bureau of Mines, Department of the Interior, for duty at Washington, D. C., and Pittsburgh, Pa.

The entrance salaries are shown above. After the probational period required by the civil-service act and rules, advancement in pay without material change in duties may be made to higher rates within the pay range for the grade, up to a maximum of $5000 a year for fuel engineer, $3600 a year for associate fuel engineer, and $3000 a year for assistant fuel engineer. Promotion from lower to higher grades may be made in accordance with the civil-service rules as vacancies occur.

Appointees must be able to conduct, under general direction, laboratory and field fuel investigations, especially in combustion, furnace design, smoke prevention, heat transmission, efficiency of fuel-using devices, and must also be able to prepare concise and intelligent reports thereon. They will also be required to assist in tests of boiler and other furnaces and of auxiliary equipment affecting efficiency in the use of fuels, and in investigations of fuel-burning methods and machinery, inspecting and sampling of fuel, and compiling of data.

Competitors will be rated on their education, training, experience, and fitness; and an essay, thesis, publication, or report to be filed with the application.

Full information and application blanks may be obtained from the United States Civil-Service Commission, Washington, D. C., or the secretary of the board of U. S. civil-service examiners at the post office or customhouse in any city.

Cadmium in Trolley Wire Boon to Electric Lines. The addition of 1 per cent of metallic cadmium to copper trolley wire produces an alloy which lasts about three times as long as the ordinary copper wire, it has been revealed in tests conducted on British and Canadian trolley lines. One stretch of double track, over which some fifty cars passed in an hour, was equipped with the two different wires, the copper wire wearing down several times faster than the alloy. The tensile strength of the alloy, for the same size of wire, is nearly double that of the copper.

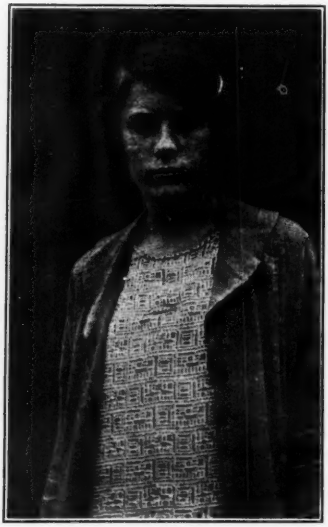
In one series of tests, reported Dr. N. F. Budgen, British scientist, copper wire after 130 days of service had worn down 6 per cent, a cadmium-copper wire of the same gage having lost only 12 per cent after 730 days of service. In another set of experiments the copper wire after 602 days had diminished 31.5 per cent and in the same interval the cadmium-copper wire had lost only 8.2 per cent. The power loss due to a slightly poorer electrical conductivity of the alloy is low.—*Science Service*

THE RELATION OF CHEMISTRY TO AGRICULTURE AND FORESTRY*

EUPHEMIA CLARK, RENO HIGH SCHOOL, RENO, NEVADA

The millions of people who inhabit this great country of ours must be fed, clothed, and housed. Our national resources are decreasing as our population increases. The chemist has always been and continues to be a very helpful friend of the forester and farmer. "The Relation of Chemistry to Agriculture and Forestry," therefore, should be of interest to every American.

The United States is a new nation, comparatively speaking. We have been prone to rely on the unearned increment of unoccupied land, but our population has now become so great that we must treat the soil with the greatest respect; it is only fair that if we expect the soil to feed us we should feed it. The plants, which are the medium through which the soil feeds us, refuse to grow and thrive unless we feed them by feeding the soil.



EUPHEMIA CLARK

Out of the thirteen elements which plants must have (hydrogen, oxygen, nitrogen, chlorine, potassium, magnesium, calcium, iron, sodium, carbon, sulfur, phosphorous, and silicon) we humans must supply only three, for Old Mother Nature has been kind enough to arrange that a sufficient supply of ten of them reaches the plants without our help. Three of them, hydrogen, oxygen, and carbon, reach the plants through air and water. The other ten, in the form of salts, are dissolved in the water that is sucked up from the soil; and, in the cases of all but three of them, the plants derive the small quantity necessary from this natural source.

The three that are left for us to worry about are nitrogen, potassium, and phosphorous. When we realize that one ton of wheat eats out of the soil about 47 pounds of nitrogen, 18 pounds of phosphoric acid, and 12 pounds of potash we know that nature can hardly be expected to furnish all the nitrogen, phosphorous, and potash needed on our planet. Consequently that becomes man's problem. When we know that these elements would be useless or fatal to plant life in their elemental form, but that

* Prize-winning high-school essay, 1925–26.

fixed in neutral salt they are essential to plants, we begin to understand how great this problem is which nature left for man to solve. Most of us would have thought, "Let the farmer worry," and forgotten that we must eat; but the chemist, ever the farmer's friend, began to worry as long ago as 1840. The German chemist, Justus von Liebig, then pointed out the possibility of maintaining soil fertility by the application of chemicals.

This was worrying to some purpose: as a result the farmer has nitrogen in the form of fertilizers to feed his plants. Nature, to be sure, didn't overlook the need of nitrogen but, unfortunately, she gave most of hers, in the form of saltpeter, to Chile, a supply that could not be depended on forever. The chemist learned how to harness the nitrogen of the air.

Chile has a surplus of nitrates, Germany of potassium; we have the surplus of phosphates. From deposits of lime phosphates in South Carolina and Florida, and from the Florida pebbles which are dredged up from the bottom of lakes and rivers, the United States has been able to supply phosphates for our plants. Moreover, it has exported about $7,000,000 worth of phosphates to feed the hungry European plants.

That was that! But the most discouraging of these plant life necessities, potassium, was still left to ponder over. To France and Germany it wasn't discouraging; for at Strassfurt and in the forest of Monnebruck, old Mother Nature donated extensive and valuable deposits of potash. (Germany had a world monopoly on potash through Strassfurt until France became owner of a deposit in the forest of Monnebruck. This was sixteen and one-half feet thick and was estimated to contain 275,000,000 tons of potash. It developed into a formidable rival for Strassfurt and put France "in the running" where potash was concerned.) The American chemist didn't give up entirely, however, and just say "Import from France or Germany." He looked around and found that from kelp, woodashes, molasses residue from distilleries, waste liquors from beet-sugar refineries, the dust from cement mills, the dust from blast furnaces and from various other miscellaneous industrial wastes we could supply ourselves with a small part of the potash which we must have. In spite of the chemist's efforts we must rely, at present, on foreign powers for most of our potash. Nature has supplied us with potash in the form of gravel (every handful of gravel contains about 10% potash) but it is combined with silica, from which it has so far been impossible to free it. The fact that the chemist has been able to do so much for hungry plants in the past makes it reasonable to hope for a future triumph when every plant shall be fed just what it needs and shall grow and thrive to the greatest extent possible. Then every acre of ground which has been sown shall produce a glorious harvest.

The chemist made it possible to feed plants repeatedly through the same

soil by the addition of chemical fertilizers, but his agricultural task was by no means completed. Plants are fed, they grow, are harvested, and while we are eating them, another generation is taking root in their place. What more can the chemist do? Like humans, plants are often attacked by disease. Sometimes microscopic organisms and sometimes perfectly well-known and visible insects such as locusts, cornworms, potato bugs, and boll-weevils eat away the life of plants. The chemist to the rescue! What crop is there which is not increased by chemical sprays? So the chemist has helped the plants by feeding and doctoring. This means he has been an invaluable aid to the farmer from whom we must buy the food which keeps us alive. If we are not thankful to him we should be.

After the crop has grown and been harvested the most marvelous power of the chemist, his creative power, comes to light. With a seemingly magic touch he has doubled the value of several crops through the channel of by-products. From corn alone over a hundred different commercial products are now made. Every year the factories of the United States work up over 50,000,000 bushels of corn into 800,000,000 pounds of corn sirup; 600,000,000 pounds of starch; 230,000,000 pounds of corn sugar; 625,000,000, pounds of gluten feed; 90,000,000 pounds of oil and 90,000,000 pounds of oil cake.

A kernel of corn is an amazing thing. There are three parts of the kernel; the germ, the body, and the hull. Each one of these breaks into countless useful things. The germ produces corn oil, which is capable of turning itself into table oil, dyer's oil, soap, glycerine, or rubber substitute, just as its commanding genie, the chemist, demands. The germ produces, also, oil cake and oil meal, which is used as cattle food. The body produces starch, gluten, dextrose, glucose, corn sirup, hydrol, tanners' sugar, cerelose, four varieties of dextrin, British gum, and amidex. The gluten subdivides into vegetable glue, vegetable casein, and gluten meal. The hull is used in the form of bran. Having thus turned the kernel into a hundred useful things the chemist, ever an economist, turned the cob into a gum suitable for bill-posting and labeling.

Another example! The chemist's power prevented waste from apples; he was so great an economist that he worried over apple cores and apple skins. He set to work and found out that apple pulp contains pectin. Pectin makes jelly jell. Behold a use for substances which everyone else had discarded!

For a third instance of this marvelous creative power consider cotton. Ever since the Greeks, under Alexander the Great, fought their way into the East and found, much to their surprise, wool growing on bushes the civilized world has used the fiber of the cotton plant. For the same number of centuries, minus about the last fifty years, the civilized world has neglected the cotton *seed* which, under the chemist's hand, turned

out to be so valuable a substance. The cotton crop of the United States for 1917 amounted to 11,000,000 bales of 500 pounds each. The chemist has added some $150,000,000 per year to the value of this crop by discovering methods of utilizing the seeds which had been used as fuel or thrown away. It would be almost impossible to name the thousands of useful things which a ton of these tiny seeds now produces. But when you know that from the linters come such things as twine, rope, carpets, absorbent cotton, smokeless powder, varnishes, and artificial silk; from the hulls, feed, fertilizer, cellulose, and fuel; from the meats, candle pitch, roofing tar, linoleum, cottonseed oil, cosmetics, oil cloth, and hundreds of other useful things, it is easy to get some idea of the variety of positions that the tiny seed has been made to fill. These magical transformations of the chemist have been of inestimable value to the farmer—to all of us.

Even here the chemist did not stop. He found that some plants which produce daily necessities were being over-worked, run to death, and that in consequence the price of necessary products was soaring out of reach. He went to work to solve this problem and succeeded through the medium of substitutes. For instance, rubber is necessary and very expensive. The chemist sought a substitute for the juice of the rubber tree. He made rubber from isoprene which he got from fusel oil (by the use of chlorine) which was in turn obtained from potatoes. One would think the problem solved, but it wasn't, for the synthetic rubber was too expensive to be of any commercial value. The success was scientific, not industrial. The chemist did solve the problem, finally, by finding the Mexican plant guayule which is now cultivated extensively to help the rubber tree produce the supply of rubber which the world must have.

In regard to sugar the chemist has solved a similar problem in a like way. In 1747, Marggraf, a Berlin chemist, discovered that sugar could be procured from beets as well as from sugar cane and thus broke the monopoly which the English had procured through the West Indies.

Thus in four ways, by feeding the soil, doctoring the plants, increasing the value of crops, and discovering substitutes where they were necessary, the chemist has proved an invaluable friend to the farmer, and through him, to all of us.

Let us now see how he has helped the forester and lumberman. When we look around us and see the thousands of daily necessities which came from the forest we realize that the relation of chemistry to forestry is no less important to us than the relation of chemistry to agriculture. When we realize that a single New York newspaper uses up two thousand acres of forests per year we can see how necessary it is for some one to encourage the trees. The chemist has done this in several ways. For instance, he has invented chemical sprays to protect the trees from disease

and he has shown us how to use every tree and each part of each tree. In the instance of paper, 90% of which is made entirely from wood, spruce, hemlock, balsam, and poplar have supplied most of the pulp. The chemist has proven that fifty other varieties can be used and that even the southern pine (heretofore regarded entirely unsuitable for paper manufacture) could be used to make wrapping paper.

The chemist has rendered another service by providing a strong wood glue which makes grades of wood hitherto discarded useful for "built-up construction."

Through such chemical products as wood alcohol and charcoal we have been able to utilize the small and crooked limbs which, before, had been wasted.

Sawdust, which has represented a great waste of the lumber industry, has been converted by the chemist into a carbohydrate food for cattle and into alcohol.

So, in countless ways, the chemist has been useful to our country's farms and forests. If each of us could do as much what a golden future would be in store for us. He has lifted agriculture from depression and saved forests from depletion. Yet he, alone, cannot solve the mighty problems of future prosperity. Let us, as a nation, give him our grateful support.

Dust in Air Gives Scandinavia Silver Nights. "Silver nights," or unusually bright twilight from sunset to sunrise, have been forecasted for Sweden this summer by astronomical experts.

Formerly such phenomena caused widespread consternation as the light was bright enough to read by in Stockholm at midnight. Many people thought it foreshadowed the day of Last Judgment. Now scientists have discovered that it is due to volcanic ash spreading through the upper layers of atmosphere and reflecting the sun's rays back to the earth. The recent eruptions of a volcano on the Kamchatka peninsula, of another in Japan, and also that of Mauna Loa in the Pacific foreshadow a recurrence of the extra brilliant twilight this summer. The Swedish landscape is ordinarily remarkable during the long sunlit summer nights, but the silver light gives it a weird beauty.

The earliest systematic observations of the gradual spread of fine volcanic ash date from May, 1883, when the entire island of Krakatoa in the East Indies was blown up by the bursting of a volcano. The explosion was heard as far as the Philippines, Hong Kong, western Australia and India, and the amount of ashes thrown up has been estimated at 18,000,000 cubic meters. By November of that year the finer layers reached Europe, causing extra red sunsets, and in Sweden the twilight was made brighter for the next three summers. The passage from the Straits to Sweden required less than three months. In 1902, after the eruption of Mount Pelee on the West Indian island of Martinique, the dust was first observed in about six weeks. "Silver nights" were observed in Sweden again in 1908, but exactly where the dust then came from it was not possible to determine, since volcanoes often erupt in isolated regions where the event is not reported.—*Science Service*

THE RELATION OF CHEMISTRY TO THE HOME*

GEORGE B. CRUMP, PINE BLUFF HIGH SCHOOL, PINE BLUFF, ARKANSAS

Somewhere in the course of many years of schooling, every person in the present day has an opportunity to study chemistry. By all means he should avail himself of this chance to study this greatest of all sciences, the chance to learn something of the common articles we use so much but think so little about. At present I am in the midst of the wonderland of chemistry, and it is the most interesting study I have. It is my hobby and I expect to make it my profession. As I progress farther and farther into the study, I realize more and more the vast importance of chemistry in the home.

GEORGE B. CRUMP

For the purpose of seeing for ourselves the relation of chemistry to the home, let us make a complete inspection of my home, typical of America.

First consider the building itself. For a starter we will make the rather broad statement that all metals used in the construction of the building, in decorating it, or used in it in any way, have been reduced from their ores by chemical means. Then the paint protecting the exterior woodwork is white lead and linseed oil, both chemical products. The mortar which holds the bricks together is composed of cement and hydrated lime, both manufactured under chemical supervision. The plaster on the walls is a mixture of various ingredients, all made by chemists. And what would we do without glass for our windows and mirrors? Glass has long since changed from a luxury to a necessity, and it was the chemist who, by improving methods of manufacture, has made this once precious material a common article.

And now we pass into the living room. The woodwork is stained with a stain made of numerous pigments, all chemical products, carefully blended. Over the stain is a varnish composed of some gum, probably synthetic, dissolved in alcohol. There is a table in a corner, and on it is a telephone, made of hard rubber. Thanks to chemistry, in general, and Mr. Charles Goodyear, in particular, rubber, by varying the amount of sulfur used, may be made hard or elastic, and not susceptible to weather

* Prize-winning high-school essay, 1925–26.

conditions. We recline in a comfortable chair whose joints are securely held together by a waterproof glue made from milk. The upholstery resembles leather, but a close examination will reveal that it is only nitrocellulose spread on some fabric and printed to make a very good imitation of leather. Over the mantel of the fireplace is a picture printed in many colors. The inks that furnish the color are made by chemists. On each side of the fireplace is a bookcase. The bindings of the books are chemically made and the paper is made from wood pulp, refined by various chemical processes. The books were printed from plates of copper made by the process of electroforming.

There is also a phonograph whose records of chemically refined wax were printed from plates made in the same way. The panel of the radio is made of beautifully polished bakelite, discovered by Dr. Baekeland, and composed of phenol, better known as carbolic acid, and formaldehyde, both common disinfectants. Its insulating properties are excellent. The keys of the piano resemble ivory, but if one of them were heated our nostrils would soon disillusion us, for the keys are made of celluloid, a very odorous compound of guncotton and camphor.

Next we invade the dining room. We walk over to the buffet and examine the silverware. It appears to be real silver, but thanks to the electrochemist, it is possible to deposit a coat of silver about 0.001 inch in thickness on some baser metal, thus giving to the people in moderate circumstances silverware that rivals the beauty of the sterling silver of the rich.

We notice some cut glass throwing multi-colored rays of light in every direction. Only the chemist would have conceived the idea of substituting red lead for limestone, potassium carbonate for sodium carbonate, and adding sodium nitrate to the batch, these compounds causing the refraction of the light rays. Then there is chinaware. Chinaware has been used for centuries, but it was the chemist who improved methods of manufacture, thus giving us chinaware that far surpasses the beauty and durability of the product of the ancients.

Now let's migrate to the kitchen. On the floor is a rug made of linseed oil and ground cork plastered on burlap, and called linoleum.

We step over to the kitchen cabinet and investigate its department of interior. (No, not a congressional investigation.) Here is pure white sugar, made so by the simple method of filtering it through charred bones. The chemist would explain that the decolorization was due to the adsorption of the coloring matter by the charcoal. There are several bottles of flavoring agents, beautifully colored. I daresay that the geneology of both flavor and color could be traced back to an humble and ugly piece of coal. We notice a bucket of lard at hand. It appears to be ordinary hog lard, but it was made by a well-known cotton-oil mill.

This is due to the fact that, under the proper conditions of temperature and pressure, and in the presence of finely divided nickel as a catalyst, hydrogen, bubbled through the liquid cotton oil, will be absorbed and will change the oil into solid cooking fat. Thus the chemist has enabled the manufacturer to utilize waste oil and supply the housewife with a cheap and good substitute for hog lard. There is also corn sirup, made from corn starch by boiling in hydrochloric acid. Next we explore the refrigerator. The ice that keeps it cool was made by circulating ammonia, an important chemical compound, through pipes. There is a bottle of milk that advertises the fact that it has been pasteurized. This process of pasteurization, first applied to preserving wines and then to making milk safe, was discovered by Pasteur, one of the greatest chemists and bacteriologists the world has ever known. Then there are various relishes and sauces that require chemical preservatives, and the baking powders are composed of chemical products.

From the kitchen we wend our way upward to my sister's room. The first thing that greets our eyes is an image of ourselves, reflected perfectly from a large mirror in a dressing table. Only the chemist could have removed the numerous blemishes from the glass, blemishes that made many a fine old lady of bygone times afraid to look at herself. It was some bright chemist who discovered that a mixture of silver nitrate and formaldehyde deposited a bright silvery coating on his test tube, and likewise on mirror glass. There are numerous articles absolutely necessary to the feminine toilette, entirely incomprehensible to the masculine mind, and all made of synthetic plastics.

In curiosity we press the bulb of a perfume atomizer. Immediately a strong odor of violets assails our nostrils. Evidently, if odors are to be trusted, the shrinking violet has become a roaring and assertive plant. However, odors are not to be trusted for some chemist won the undying gratitude of the perfumer by inventing a synthetic odor much cheaper and much stronger than the natural product.

We open the door of the clothes closet and a riot of color greets us. These many colors that so brighten and enrich our lives come from coal tar, and it was a seventeen-year old boy, William Perkin, while working one Easter holiday, who discovered the first coal-tar dye, giving us a variety and range of colors never before known, The silk in the dresses might be real silk, but it is quite likely that the fibers are wood-pulp cotton, or guncotton. It was sold for silk, and the illusion is so perfect that only an expert could detect the fraud. On the dresses are some brightly colored buttons, made of the same substance that so securely holds our furniture together. Casein, mixed with aniline dyes, is allowed to harden in a formaldehyde bath, forming an excellent plastic for all uses.

In my own room there is nothing of importance except a camera and some developing fluids. The film in the camera is composed of several common chemical compounds, while the process of printing and developing involves numerous chemical reactions. It is a far cry from the crude methods of Talbot to the modern methods, but they are both alike in one respect—they involve chemical reactions galore.

The next stop is the bathroom. All the fixtures are a gleaming white resembling porcelain, but there is quite a difference, chemically speaking, between porcelain and this whiteness.

We pick up a piece of sodium stearate, otherwise known as soap, and recall the numerous processes involved in the manufacture of this article and its by-products.

When we open the door of the medicine cabinet, a row of bottles greets us. There is a white powder, eaten by those wishing a painful death, known as mercuric chloride, corrosive sublimate, or bichloride of mercury. Then there is bichloride's little brother, not a bad sort of fellow, called mercurous chloride, or calomel, and used by physicians to stimulate a lazy liver. There is also a popular remedy, for minor aches and pains, called aspirin. It is an ester of acetic acid and a product of the destructive distillation of wood and salicylic acid, coming from coal tar via carbolic acid. Yes, there's some carbolic acid in the cabinet, too. There are various other medicines, all of chemical nature and manufactured by chemists.

Having completed our survey of the house, there is but one conclusion to draw, that chemistry is absolutely necessary to the modern home. Without chemistry the home would, as would everything else, sink back into the darkness of the Middle Ages, the age of superstition, uncleanliness, and barbarity. Without chemistry we would have no medicines to cure the sick, no dyes, none of those things that contribute so much to health and happiness. Some people, with a slightly pessimistic view, say that it is only through ideal conditions of home life that the youth of the nation may be saved from the ravages of drink and the like. If the rising generation needs saving, the chemist is the one responsible for the future greatness and power of the nation, for he is the only one able to create the proper conditions of living necessary for salvation. A man once wrote a song which said, "Be it ever so humble, there's no place like home." Now I say, "Were it not for chemistry, there wouldn't be any home."

Acknowledgment

I wish to acknowledge gratefully the great aid rendered in the writing of this essay by Edwin E. Slosson's "Creative Chemistry," and the two books, edited by H. E. Howe, entitled "Chemistry in Industry."

THE RELATION OF CHEMISTRY TO HEALTH AND DISEASE*

VINCENT A. MCKIVERGAN, TECHNICAL HIGH SCHOOL, PROVIDENCE, RHODE ISLAND

Not long ago there was enacted in the very heart of the largest city in America a tragedy which had for its principals two people—a father and his son. The former was a specialist in children's diseases, the latter an only child. Stricken with diphtheria, the boy lay on his bed, his life slowly ebbing out with the tide of what was then an invariably fatal disease. Helpless and hopeless the father stood at the bedside; helpless because the science of medicine offered him no remedy for that particular disease; hopeless because the disease had up to that time proved fatal, with practically no exception. And the child died, seemingly deserted by medical aid in his unequal battle against disease. But although the science of medicine had not offered, nor was it able to offer, any practical remedies in this particular case, just as in other like cases that preceded or immediately followed it, yet medical science was not unaware of the appalling situation. Even at that time researches were being conducted in a desperate endeavor to find the elusive remedy for that particular disease. The result of these tireless and exhaustive researches was the discovery of our present-day diphtheria antitoxin which has proved such a relentless foe to the diphtheria germ and made man victor over its ravages in practically every case.

VINCENT A. MCKIVERGAN

Yet we must not think that this great advance in our ability to successfully cope with disease has occurred only in the isolated disease, diphtheria. We could just as well cite cases of a dozen or more diseases which but a half a century or less ago were always fatal—afflictions such as malaria, yellow fever, anthrax, typhoid and typhus fevers, malta fever, and puerperal fever, all of which, once disastrous to an amazing degree, are now attended by unbelievably low mortality rates. Immediately we ask, "What is it that has taken place within the lifetime of our older men of science, that so many diseases, once dreaded and unconquerable, are now in turn defeated by aids so aptly furnished by science?" The answer may be summed up in one word—coöperation—coöperation

* Prize-winning high-school essay, 1925–26.

of the sort that should exist between medicine and its natural parent—chemistry.

Chemistry, science tells us, is nothing other than the study of the fundamental transformations of matter. So, too, if the definition of medicine be reduced to its lowest terms, it would be found to be nothing other than the study of the fundamental transformations of living matter, that is to say, matter as found in animal and plant life. Yet despite the fact that these two sciences are concerned with the changes taking place in the same medium, matter, it is only within recent times that scientific men have realized the imminent and vital connection between these two branches of science. It is sad, but none the less true, that chemists in the past have concerned themselves with industrial chemistry and only too willingly have abandoned the field of medicine to the medical man, who in turn has sought to employ all but chemical investigations for the solution of his problems. No leaders on either side seem to have realized that a bridge lay between the two sciences, merely awaiting the footsteps of the scientific adventurer. This is the lack of coöperation deplored by all true scientists.

The history of medicine abounds in numerous examples of this lack of coöperation. Amyl nitrite, that drug so indispensable in the treatment of heart neuralgia (angina pectoris), was discovered by a chemist in 1844, but it was not until 1867 that medicine made use of it. Ether was discovered in 1540 by Valerius Cordus who named it "oleum Vitriioli Dulce." Yet three centuries elapsed before its initial use as an anesthetic. Chloral hydrate was known to chemists for almost forty years before Liebreich, a medical man, recognized its anesthetic value. Nitrous oxide was discovered by Priestley, a chemist, in 1776, but it was not until 1844 that it was used successfully to produce unconsciousness. The story of the discovery and initial uses of those drugs which are specific remedies for epilepsy, hookworm disease, syphilis, and other maladies is but a repetition of this lack of coöperation between these two sciences.

Medical science, certainly up to the beginning of the present century, has not fully realized the value of chemistry. Physicians have made their comforting presence felt at the bedside of their patients, but their knowledge has contributed very little to our present understanding of the nature and origin of disease. The ordinary physician, like the engineer, has made use of scientific results for the benefit of mankind, but he has originated little for himself. He has been able and practical, good at diagnosis and clever in manipulation, but withal an empiric, wanting in scientific ideals and only very occasionally a contributor to scientific knowledge. Today, however, the medical man is beginning to acquire this knowledge of the cause of disease, the means of conferring immunity, or the providing of antitoxins, by the specific action of which the

destructive power of disease germs is annihilated or at least reduced to a minimum. All these things are being brought into medical service because at last medical men and chemists are meeting upon common ground.

Let us note some meritorious contributions to the service of medicine made by chemistry during just the infancy of this new alliance. When Sajous, a chemist of Philadelphia, insisted in 1813 upon the existence and importance of internal secretions and ductless glands, the medical fraternity, almost to a man, was inclined to think the idea fantastic and not worthy of further investigations. It remained for George Murray to demonstrate by his convincing experiments on the thyroid gland in 1895, that the doctrine of internal secretions was not only sound but also offered a solution for the cure of many human ills. Up to this time physicians who removed goiters were bewildered at the frequency with which tetany, always bringing death, had followed the excision of this gland. This new doctrine of internal secretions explained this sad occurrence when it showed the presence of parathyroid glands, adjacent to the thyroid gland, and which the surgeons in their ignorance had removed, little knowing that without them life could not go on. Chemical investigations of this doctrine of internal secretions also successfully demonstrated that when the thyroid gland fails to secrete normally from birth it gives rise to the condition called cretinism, a form of idiocy. If this thyroid-gland secretion becomes subnormal later in life, the condition we call myxoedema arises, accompanied by degenerative changes in mind and body. Chemistry not only showed the occurrence and cause of all these things but went further and showed to the medical men how these abnormal conditions could be compensated for by simply administering, under certain precautions, an extract from the thyroid glands of sheep.

Another notable contribution of chemistry has to do with the secretion known as adrenalin. This substance receives its name from the fact that it is secreted by two small glands which lie just over the kidneys, hence, named "ad-renal" glands. Although the presence of these glands was known from the year 1564 it remained for chemistry, in 1901, to call the attention of the medical world to the fact that they have a vital place in pharmacology. As a result, adrenalin is now used in surgical operations to raise the blood pressure, thus reducing the possibility of shock. In addition it is commonly used as a circulatory stimulant, being used in such cases by injections directly into the heart of the patient. Lives of many newly born children have been saved by this later use.

Still another vital contribution of chemistry to medical therapeutics is the much used and highly valued substance, insulin. Used in relatively small quantities it goes far towards accomplishing the work which a diseased pancreas found itself unable to do, thereby causing the diabetic condition to be alleviated. To this substance thousands of diabetic

patients owe their prolongation of life, and probably upon this substance, which is obtained from the pancreas of pigs, must be based any hope for an absolute cure of diabetes. It is interesting to note at this time that only as recently as January 22, 1926, Professor Abel of Johns Hopkins University has succeeded in isolating insulin in its crystalline form and made it possible to administer it in an even purer extract. His discovery places the possibility of manufacturing this substance synthetically within the range of probability. Such synthetic manufacture would give us a far purer product, materially increase the benefit, and lessen the dangers of its administration.

A description of the subject of antitoxins and bacteria is nothing more or less than a chemical thesis, for in this field, too, chemistry has always led the investigators. To Pasteur, the discovery of the existence of bacteria must forever be attributed. Here we have a scientist skilled in chemistry and knowing little of medicine, yet producing in his laboratory the solution of huge medical problems. Had he not discovered the presence of bacteria and their danger, operations as we know them today would not take place and antitoxins would be unknown. As a direct result of Pasteur's bacteriological investigations the medical man today is provided with antitoxins for smallpox, hydrophobia, diphtheria, whooping cough, etc. Hence it is the exception rather than the rule today that any of these diseases should result fatally.

An entirely new field has been developed within recent years by chemists interested in medical problems. This is the field of vitamins, those mysterious things contained in many of our foods and which are so necessary to health. Chemistry has shown that the body does not develop or prosper until and unless these vitamins (there are several varieties) are taken into the system in sufficient amount. Today we know in just what kinds of food these vitamins are present and apply this knowledge to nutritional problems. To date, the most gratifying results have been obtained in dealing with infant and child life. One direct benefit is our success in reducing the frequency of scurvy and rickets, two serious diseases of young life. Here again the surface of the problem has been but merely scratched.

The numerous questions of body nourishment, in general, are being answered today to an ever-increasing extent by chemistry. An unbelievable advance has been made in chemical analysis of food constituents so that we now have much scientific knowledge of carbohydrates, fats, proteins, amino acids, etc. Even the least optimistic of us agree that possibilities of huge advances in this study are seemingly limitless. The additional responsibility of carrying on this work, too, has been assumed by the chemist, and we await his further announcements with eager anticipation.

In all these ways chemistry has demonstrated its generosity to the science of medicine! It has endowed medicine with its best anesthetics, given it specific remedies for hitherto uncontrollable diseases, furnished it with much knowledge of internal secretions and ductless glands, provided such wonderful things as adrenalin and insulin, taught it the value, uses, and dangers of bacteria and antitoxins, and introduced to it the study of vitamins together with the broad considerations of metabolic processes. All this chemistry has done within less than half the usual span of life allotted to man. And yet we know that this is just a beginning and that chemistry promises much more. Is it any wonder that we simply marvel at the powers of chemical science?

The sub-branches of medicine (pathology, histology, embryology, and bacteriology) have succeeded fairly well in solving the special problems in their particular fields. Problem upon problem, however, has been reduced by them to a question of cell structure and then simply left hanging in the air because their knowledge of cells has not been completed. The cell is the unit of structure in all life, be it plant or animal. To it, therefore, we must turn for a solution of the fundamental secret of life. This cell-structure problem over-shadows perhaps all other problems submitted to chemistry by medicine. Perhaps the greatest step towards the discovery of this secret of life was announced on January 27, 1926, by Dr. D. T. MacDougal, director of the laboratories of the Carnegie Institute at Tuscon, Arizona. He has perfected a real working model of the living cell, a model that ingests and digests water and food material with resultant growth. This artificial cell, however, is not perfect and it may be that we shall never produce a real living cell as it exists in plant and animal life. Still, here is a distinct and worthwhile step made by chemistry towards a satisfactory answer to the question, "what is life?"

The purpose of all scientific study is to further our knowledge of ourselves and the world in which we live. This knowledge we employ in an effort to better ourselves and our environment. In other words, we seek to increase our welfare. Human welfare consists of many things—health, shelter, clothing, food, mental development, recreation, and many other factors of lesser importance. We readily agree that of these component parts health is by far the most important. With it, the other things necessary to a comfortable, happy life are acquired with relative ease; without health, the other things interest us but little. Since health is the greatest need in our human welfare and since the service of science is in direct proportion to its ability to better this welfare, chemistry is choosing but the obviously best path in concerning itself first of all with problems of health and disease. The only wonder is that chemical science concerned itself with solely industrial problems for such a procession of

years, quite ignorant of this path leading to its greatest service. Now that chemistry and medicine are advancing in their alliance we can reasonably anticipate even greater benefits than they have brought about in what has been just the infancy of their union.

May the sciences of chemistry and medicine ever find, in each other, inspiration and a mutual desire to exert their combined efforts in the labor of lessening disease and developing the natural powers given us by a benevolent Creator!

Step Taken toward Understanding Tuberculosis. An important step toward the understanding of tuberculosis may be taken as a result of researches by Dr. Florence B. Seibert, of the University of Chicago and Otho S. A. Sprague Memorial Institute, who has reported to scientific publications the discovery of the chemical compound in tuberculin that elicits the skin reaction.

Tuberculin is a preparation of various forms and modifications made from cultures of the bacterium that causes tuberculosis and is commonly used as a test for the presence of the disease in both men and animals. Ever since the time of Koch, the famous bacteriological pioneer, many experimenters have attempted to determine just what it is in tuberculin that brings about a skin reaction in those suffering from tuberculosis.

Dr. Seibert has now found and crystallized a protein substance contained in tuberculin that carries with it the ability to produce the characteristic reaction.—*Science Service*

Germany Admitted to International Research Council. The scientists of the Germanic countries, enemies of the Allies during the war, have been invited to sit in the councils of international science. The International Research Council meeting has by unanimous vote of the twenty countries attending invited Germany, Hungary, Austria, and Bulgaria to join the council. This action will bring all of the principal nations into the circle of international science and end the exclusion hitherto suffered by enemies of the allied nations. The matter of changes in the basis of dues of the various countries in the council was left for later decision by the various international unions affiliated with the International Research Council and the Council officer Dr. Vernon Kellogg, permanent secretary of the American National Research Council, represented America at the meeting and supported the resolutions admitting Germany.

The action of the International Research Council admitting the Central European Powers to its membership brings to fruition the effort of protagonists for international scientific amnity to consolidate the relationships of the international scientific world. The International Research Council was organized during the World War by representatives of the Allied and neutral nations and at that time membership of the enemy countries was out of the question. Since, however, the International Research Council replaced the older international organizations that were disrupted by the outbreak of the war, a strong sentiment grew up for the admission of the former enemy countries just as soon as the war feelings died away. Last year the American delegation supported by England, Sweden, Denmark, Norway, and Holland, urged the admission of the former enemy organizations, but although those nations were in the majority, a minority, represented chiefly by France, Belgium, Czecho-Slovakia, and Poland, together with the rules of voting, prevented the admission of Germany, which has now been accomplished.—*Science Service*

THE USE OF CHEMISTRY IN OUR NATIONAL DEFENSE*

Wallace Herrick, Mitchell High School, Mitchell, South Dakota

In a discussion of the use of chemistry in our national defense it would seem that we should discuss its uses in the defense of our industrial supremacy as well as from a military standpoint. Upon this point Michael Pupin, the great scientist and inventor, says, "We usually think of the army and navy when we speak of national defense, but there is another army, and that is the army of scientific men in the U. S." This discussion will be written upon that basis and with the idea of showing the great contrast there is between the uses of the substances discovered by science as tools of warfare and in the defense of our industrial supremacy.

Wallace Herrick

When the first explosive, gunpowder, was discovered in the middle ages by some unknown chemist, it found a place ready and waiting for it. Men were anxious to be able to fight without getting near each other. They had devised all sorts of schemes to apply force to an object suddenly to make it go a long distance, from the crude Roman slings to the bowguns of medieval times. Although gunpowder was at first looked upon with suspicion, as has been every new departure, it has become one of the most widely used substances in all varieties of weapons.

All explosives operate on the same general principle. Substances are provided, which, when they are ignited, burn so suddenly that the gases formed provide a great deal of energy through their sudden great expansion. Once this important principle had been discovered, it was a comparatively simple matter for the chemist to produce new and better applications of it.

One of the most widely used of these recent developments is dynamite. This explosive is composed of wood meal, nitrate of soda, and nitroglycerin, which is made up of carbon, hydrogen, oxygen, and nitrogen. When the necessary heat is supplied, either through percussion or a spark, the nitroglycerin breaks down. The nitrogen and part of the oxygen remain free, while the rest go to form carbon dioxide and steam. This chemical action and the resulting pressure is sufficient to raise the heat to about

* Prize-winning high-school essay, 1925–26.

6300 degrees Fahrenheit, which is enough to burn the rest of the material, producing yet more gas and heat.

The energy developed by the attempts of these explosive gases to expand is utilized in many ways. It is used in torpedoes, bombs, and guns to destroy, and in mining and similar pursuits to construct. In the torpedo an explosive is packed into an iron shell to an exact pressure, sped on its way by a wonderful air motor, and fired by a very delicate clockwork. Thus it is prepared to destroy.

On the other hand in mining it is placed in its firing-hole by the hands of a day laborer; rammed down with a stick; and set off by closing an electric switch. There certainly can be little comparison between the elaborateness of its military use and the simplicity of its industrial use. In all substances which are products of the chemist there is not the same difference in method of use, but fully as great a contrast in their use as with explosives.

Another substance which is possible only through the chemist is poison gas. Its use in war is plain to all but its use as a protection against disease is a more recent and more wonderful application. The first use of this substance for any purpose on a great scale was during the World War. Before this time the nations had realized the horrible possibilities of this substance to such an extent that they had put a very strict ban upon its use. So strict had been this ban that none of the chemists had thought it worthwhile to investigate concerning either these gases or protections against them, until Germany launched her program of atrocities.

During the first period of use the gas used almost universally was chlorine. This was considered especially effective because it was heavier than air and made trenches and dugouts untenable. The chemists of France and Great Britain immediately set to work and devised the first gas mask (aside from the wet cloth tied over the mouth and nose) which consisted of an ash which neutralized the chlorine, arranged so that the air breathed passed through it.

The next few years of the war saw great development along this same line, the chemists devising new gases and then making a protection against them. At present some of the chemists of our country have devised a gas which is so deadly that a few drops of the liquefied gas would kill every living thing in a city block. One can easily imagine the terrifying ease with which a few aeroplanes equipped with this gas could subdue any of the great cities of the world.

The use of poison gas as a protection against disease is one of the most wonderful achievements which the chemist has attained. To take a substance which is very deadly, and was devised to kill, and to use this substance to cure is certainly an achievement of which any body of men

can be proud. At the present time chlorine, which was used with such telling effect at the beginning of the war, is used to subdue that disease which we all suffer from at one time or another, colds. If this gas is inhaled in proper quantities, there are several industrial firms which are willing to practically guarantee a recovery. With this use of chlorine as a basis from which to work, what cannot be done with more poisonous gases in treating more stubborn diseases? Is it not apparent from the two uses given that poisonous gases may have as widely varied uses in our national defense as any other substance prepared by the chemist?

Another great field of endeavor upon which the chemist has entered is that of metallurgy. The most outstanding of his sucesses in this line are the production of Bessemer Process steel and of that new wonder-metal, duralumin.

The story of the production of Bessemer Process steel is one which indicates very clearly the place which the chemist has made for himself in both industrial and military defense of our country. The production of steel from pig-iron is the present chapter in the story of man's relation to iron, which began when men first learned that by heating certain earths and shaping them while they were hot they could be made to serve as weapons and utensils. This use of more or less crude forms of iron continued until 1854.

In 1855 Henry Bessemer, an Englishman, patented a process for the conversion of iron into steel. The converter which is used is shaped like a huge egg with the small end sliced off. The molten metal is poured in while the converter is on its side. When the converter has been tipped up level, air is forced through several pipes in the bottom and thus air is forced up through the molten metal. The oxygen in the air acts with the carbon, phosphorous, manganese, and silicon in the iron and these are driven off as gases. When this process was first tried they tried to take out these substances only to the right amount but they later discovered that it was easier to get the iron pure first and then add any substances which were needed to give it the right fiber. Without the chemist there is no hope that this process could ever have been worked out, since it was only through his caréful analysis that the experimenters were able to discover what minerals were necessary to give the steel the correct fiber of crystallization to give it most strength.

The aid which this process adds to our national defense, both industrial and military, is inestimable, and here, again, the uses to which this substance is put are very contrasting. Our great guns are made of a core of very high quality cast steel, which is wound around and around with the very best steel wire which can be obtained. Without this very high grade of steel the guns would be utterly impossible on any such gigantic scale as they are made today. But other instruments besides

those used to take life are made from this same steel. These are the instruments of the surgeon. Without this high-grade steel this too would be impossible since the instruments must be of very good temper and very keen.

The other great venture into the field of metallurgy, which is chemistry's latest achievement, is the manufacture of duralumin. This new wonder-metal is one of the most remarkable alloys which has lately been discovered. It is composed of 94% aluminum and the other 6% is copper, manganese, and magnesium. According to recent tests it has been found that it has three times the weight-efficiency of hard steel. With this wonderful recommendation from tests it is not surprising that it has come up to the same standard in actual use.

Because of its use in aircraft of all sorts, this metal is also equally useful in both the industrial and military defense of our country. It has made more practicable the aeroplane which carries the battle into the territory of the enemy; which drops its bombs of death-dealing gas upon a great city to reduce it to defeat; it helps in spotting the shots of the big guns, which tear men to pieces as easily as though they were ants. On the other hand it helps to speed upon their way the thousands of important letters of the country and thus binds it into more of a homogeneous mass; it helps rush orders from a distance faster than any other country's orders are rushed; it helps to carry the wounded to the hospital and thus saves many a life. With all these achievements in both lines of activity it is easily seen that chemistry has performed a modern miracle which is as useful and as swift as were Aladdin's genii. To have achieved this is to have achieved much in the defense of our country.

To make human life possible we must have nitrates, and to take life easily we must again have nitrates. With this great group of chemical compounds there exists the same chance for contrasting uses as is the case with so many other of the great groups of substances. Nitrates are a necessary ingredient of all plant food and of all practicable explosives.

The compounds which are used under this wide range of heads are all composed, in part, of the chemical radical, NO_3. The smokeless powder used in practically all varieties of guns is made by combining nitric acid with cellulose and then treating this product until it becomes the familiar form. Picric acid, a French product which is very explosive and gives off a very poisonous gas, is formed from carbolic acid and nitric acid. Once again, the explosive with the laconic name, T.N.T. (which means trinitrotoluene), is made by combining toluol and nitric acid. When the chemist had discovered so many wartime uses for nitrates, the next thing to do was to discover a wartime supply, since there are no deposits easily obtainable in time of war.

When this problem was first brought up the chemists knew that there was a vast supply of free nitrogen in the air if they could only find some way of getting it out and into some usable form. A process was worked out so that when an electric arc was passed through the air a nitrogen-oxygen compound and water were formed, which united to form nitric acid. However, this electric arc method is five times as expensive as the cyanamide method which was discovered later. This process is the most practical which has been discovered and is used in the Muscle Shoals plant. The nitrate is formed by first making calcium carbide which acts with the nitrogen of the air to form cyanamide. With this process, evolved by the brains of our chemists, put into practice at the great Muscle Shoals plant the United States need never fear a war-time shortage of nitrates.

This great supply of nitrates obtainable from the air can be used for many things beside war. The chemists and horticulturists have found that by adding nitrogen to the soil in one form or another the crop yield can be increased about 50 per cent. For this reason the farmers plant alfalfa and clover in worn-out land since both of these crops add nitrogen to the soil instead of taking it away. The supply of nitrates from Chilean deposits form so cheap a source that it is improbable that the present form of extracting nitrates from the air will ever be used to any great extent for crop fertilization, but it is invaluable as an asset to have this great supply to draw upon in a time of need.

This short discussion has been based upon the idea that chemistry has promoted the defense of the nation through military and industrial development. This alone is not all which chemistry has done. Military protection is necessary to industrial development, and on the other hand, prosperity due to the development of the nation's industries is necessary for carrying on military defense. Thus the uses of chemistry in both of these fields act and react with each other until chemistry becomes one of the most important factors in the nation's growth in its industrial and military defense.

Fifty Tons of Iodine Made from Seaweed in 1925. The seaweed collected along the Breton coast brings in the tidy sum of 30,000,000 francs yearly which at pre-war prices meant $5,000,000 a year.

The first factory for the manufacture of iodine, its most valuable product, though seaweed is also an important source for potassium and sodium, was established as long ago as 1829 at Conquet in Brittany.

Since it takes a ton of fresh seaweed, approximately, to make a pound of iodine, according to figures given by M. Maurice Deschiens in a recent address before the French Society of Industrial Chemistry, the huge amount of seaweed necessary to make the 50 tons of iodine turned out in Brittany in 1925 causes its collection and transportation to be one of the heavy factors of cost.—*Science Service*

CHEMISTRY IN RELATION TO THE RUBBER INDUSTRY*

MARGARET COX, ST. ROSE CONVENT, LA CROSSE, WISCONSIN

A hundred years ago the rubber industry was unknown; today it ranks as the fourth industry in this great country of ours, being outranked only by the manufacture of steel and iron, of woolen goods, and of cotton goods. The substance, rubber, a hundred years ago was little more than a mere curiosity; today it is classed with the basic materials in factory and home. We naturally ask, "What has brought about the marvelous promotion?" The answer, simple but true, is, "The science of chemistry."

MARGARET COX

Every step toward the utilization of the sap of the Hevea Braziliensis, or rubber tree, involves chemical processes. We need only follow the history of the rubber industry to be convinced that without chemical science it could never have sprung into existence.

Although rubber was known to the Peruvians and Chinese at an early date, it was not brought to Europe until the beginning of the eighteenth century. The first mention of it is made by Herrera in his account of the second voyage of Columbus, wherein he speaks of a ball made from the gum of a tree and used by the Indians in playing a game. "This ball," he said, "was comparatively light, bounced, and was not injured by water."

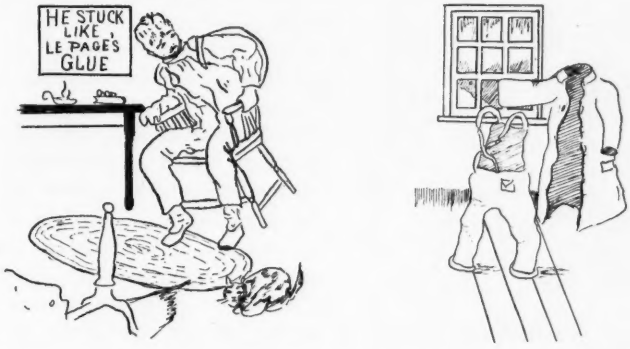
The Spaniards brought scores of these balls back with them for their various ball games at home, little dreaming of the marvelous part the little rubber ball would take in the world's work and play and welfare of today, much of which would have been impossible without it.

For centuries the new substance served no other purpose in the civilized world than that discovered by Dr. Priestley about the year 1770; namely, the rubbing out of pencil marks. It is true that as early as 1730 the Frenchman, La Condamine, found the people of Quito water-proofing cloth with latex, the juice of the rubber tree. They also coated bottle-shaped molds with it and, when the gum hardened, broke the mold, shaking the pieces out of the neck, leaving an unbreakable rubber bottle. It is said that Lisbon began to import some of these crudely fashioned

* Prize-winning high-school essay, 1925–26.

articles, and that, as early as 1755, the King of Portugal sent to Brazil several pairs of his boots to be water-proofed. A few years later, the government of Brazil sent him a complete suit of rubber clothes. But for all that, the elastic gum was, for the most part, only a curiosity and few people knew of its existence.

At the beginning of the nineteenth century, Brazil was the only country manufacturing rubber articles, and her best market was North America. Rubber shoes, waterbottles, powder flasks, and tobacco-pouches found buyers here, and the demand for rubber shoes grew steadily. Then, in 1833, the Roxbury India Rubber Company of Roxbury, Massachusetts, organized as the first in the United States to manufacture water-proof clothing. Almost over night people grew enthusiastic over the new rubber articles, but soon the bubble burst. For while the early rubber products, such as coats, life-preservers, shoes, etc., were water-proof

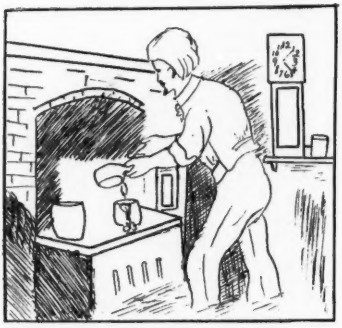


and serviceable under favorable conditions, they did not wear well and were almost as sensitive to temperature as molasses and butter. A man wearing a pair of rubber overalls and sitting too near a warm stove found that his chair rose with him when he attempted to rise. Rubber coats would stick together or melt in the heat of the sun, and break to pieces in cold weather. The secret of fabricating rubber lay hidden as yet.

The discovery of the secret was left to the inventive genius and untiring effort of an American, Charles Goodyear, who, for ten years, persisting in his indefatigable research, employing numberless chemicals and processes, in the face of many a heart-breaking failure, wrought the miracle which is as fundamental to the manufacture of rubber as is the use of yeast in the making of bread. Goodyear discovered that mixing sulfur with rubber at a high temperature causes it to lose its stickiness in warm weather and its brittleness when the weather is cold. The process was called "vulcanizing" from Vulcan, the Roman god of fire.

This epoch-making discovery in the history of rubber was patented by Goodyear in the year 1844, the same year Morse sent his first telegram. Ten years previous to this Goodyear had been using nitric acid to get rid of the stickiness of rubber, but with little success. Goodyear's wonderful discovery justly takes its place beside those of the seven wonders of the modern world: Watt's steam engine, Morse's telegraph, Bell's telephone, Ericsson's Monitor, the Pasteur discovery of bacteria, the gas engine, the electric dynamo, and airplane.

Nor was the mental exertion all that his discovery cost Mr. Goodyear. Like nearly all other great discoverers and inventors he had to face poverty and deprivation. Viewed from this angle, his contribution to the growth of the rubber industry cannot be measured in dollars and cents. His sixty or more patents for his processes and uses of rubber were hotly contested in courts; and the most famous of his suits was defended by Daniel Webster and opposed by Rufus Choate, two of our country's greatest statesmen. Webster won the day for Goodyear.

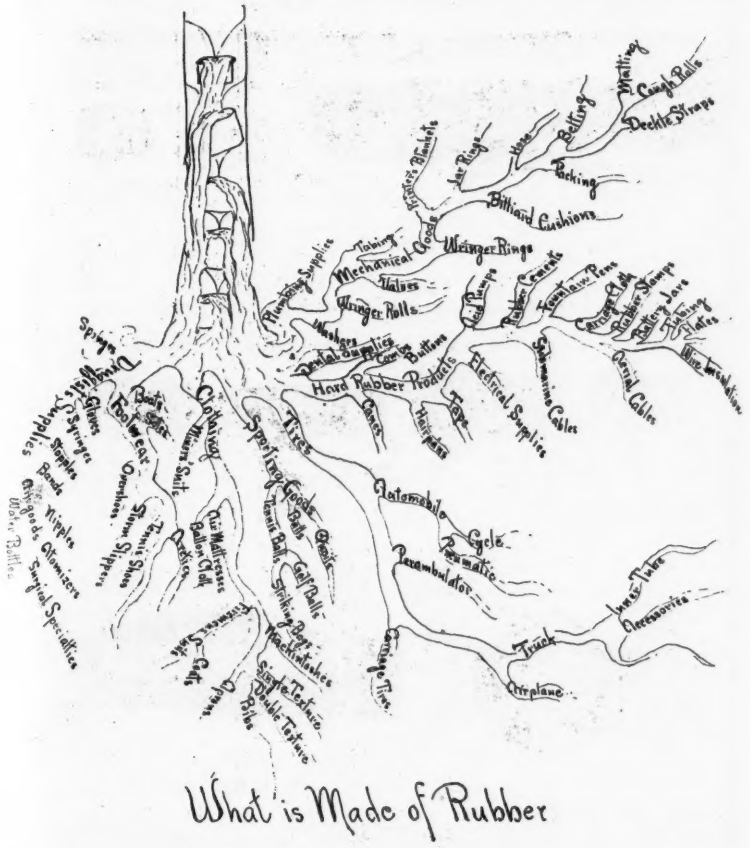


The long-sought discovery made by Goodyear which was so essential to the manufacture of rubber products was immediately followed by a rapid development of the rubber industry such as has never been equalled in any other before or since. It was given an unprecedented impetus by the advent of the automobile, and the development in every other branch of the manufactured product has been almost equally marked.

Rubber on account of its varied and important characteristics is one of the most useful products known. It is used for some purposes because it is elastic, for others because it is air-tight and water-tight, for others because it is a non-conductor of electricity, for others because it is adhesive, for still others because it is shock-absorbing, and again because it can easily be cleaned.

One of the first things given to the infant is the rubber nipple and he cuts his teeth on a rubber ring; after all the teeth are gone in old age, rubber again lends its service in the form of the rubber plate for false teeth. Millions of motorists and cyclists speed through our vast country from ocean to ocean on the noiseless cushion-like rubber tire. Rubber balloons float among the clouds, and submarines plough through the mysterious depths of the ocean propelled by electricity stored in marvelous rubber cells. Sheathed in rubber, lightning, that dread angel of death,

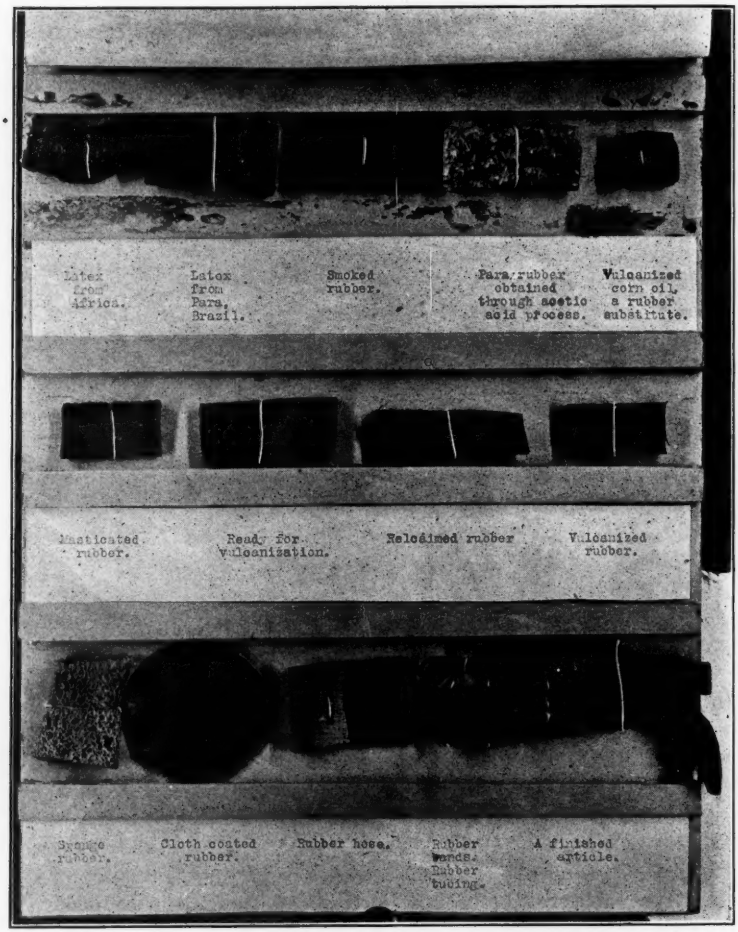
passes by our homes without doing any harm and again in another capacity, it gives us light and heat and carries our messages with truly wonderful speed. In his rubber suit the diver disappears fearlessly beneath the ocean surface in quest of the treasures of the deep; while on land and sea the same suit offers protection against storm, wet, and



cold. The rubber air-brake hose on railroad trains help to make the life of the traveler safe; fire hose help to save our property, and garden hose carry refreshment to the withering plant. Doctors and dentists use rubber in various ways; and the hospitals would be at a loss without rubber sheeting, water bags, rubber gloves, rubber tubes, etc. Rubber-cored balls, tennis balls, and golf balls give enjoyment and health to millions. Rubber, indeed, has become one of the essential basic materials

of our living needs today, and it cannot be denied that the various uses which rubber serves owe their origin to the industrial chemist who has led the way in finding new ways to produce useful articles.

The total production of rubber products in dollars and cents has grown



from a negligible figure in 1843, and from over $25,000,000 in 1879 to a possible $1,250,000,000 in 1925. So vast an industry, so essential a need to the prosperity of our modern world, could not with safety be left to depend on the uncertain source of supply in the dangerous and death-bearing fever-regions of the Amazon jungles, and as early as the year

1800 the idea of a rubber plantation was born. The story of its success begins with an Englishman, Henry A. Wickham of London, who first planted the rubber seeds in the botanical gardens of Queen Victoria at Kew, England, and later in the far East, Borneo, Ceylon, and Malaya. Today these rubber plantations—wonderful fields of activity for the chemist—cover an area of more than 3,000,000 acres with an output ten times as great as that of the so-called "wild rubber" of Brazil. There is a curious coincidence in the fact that Wickham's idea concerning the rubber plantation came to him about the same time that men in America began to experiment with the "horseless carriage."

The greatest single rubber plantation is on the island of Sumatra. An American company owns this plantation. Here 20,000 people are employed in caring for more than 5,000,000 rubber trees. Scores of chemists and botanists constantly study tree diseases, methods of increasing the yield, and other problems of growing fine trees that will produce the highest possible grade of rubber.

Recently Mr. H. Firestone of the Firestone Rubber Company of Akron, Ohio, the largest rubber plant in the world, has placed an investment of ten million dollars in a rubber plantation in Liberia. This will open a new field of activity for the chemist in behalf of the rubber industry.

There are a great many operations necessary between the gathering of the latex, the juice of the rubber tree, and the finished rubber coat or shoe, and the chemist is a busy man at each operation. The old time method of simply drying the juice over the fire or by the heat of the sun has been wonderfully improved by the chemist. The juice is now run into vats of acetic acid, and the clean pure rubber rises to the top like cream in a can of milk. Moreover, as it is impossible to make out of rubber alone any article, a shoe, for instance, that will withstand the extreme temperature changes, certain amounts of sulfur, litharge, and other ingredients must be determined by the chemist to give a satisfactory material before it is vulcanized. Vulcanization consists essentially in heating rubber mixed with sulfur at a temperature varying with the different mixtures from 260 to 300 degrees Fahrenheit. Over-vulcanized products lose their elasticity; under-vulcanized products yield to pressure and tension.

Not only has the chemist pointed out the surest means of producing the best grade of rubber; he has also made possible an artificial preparation of rubber which for some purposes is more serviceable than the genuine article. Thus vulcanized corn oil is used as a substitute for rubber. Mixed with pure rubber it gives the latter greater durability and elasticity which makes it very serviceable for manufacturing boots, shoes, garments, belting, and hose. Besides it lessens the cost. Moreover, the chemist has led the way to change rubber to ebonite which is used in the manu-

facture of combs, hairpins, canes, etc. This substance is very hard and is very much like ebony in appearance.

Just before the World War, it was discovered that rubber has the same percentage composition as the liquid hydrocarbon isoprene (C_5H_8) which boils at thirty-seven degrees Centigrade. By heating this chemical below one hundred degrees it changes into a rubber-like substance which can be vulcanized. During the last years of the war, automobiles in Germany were run on synthetic rubber tires.

In 1919 the two chemists, F. Hoffman and C. Coutelle, at the Elberfeld Co. laboratories, succeeded in making synthetic rubber not only from isoprene but also from two other hydrocarbons; namely, butadiene and dimethyl butadiene whose boiling points are, respectively, four degrees Centigrade and sixty-nine degrees Centigrade. A multitude of objects such as tires, electric cable insulation, and rope have been made from these artificial polymers. Even if the German chemist did not succeed in underbidding the price of natural rubber, he did succeed in making it impossible for John Bull to raise the price as high as $5.00 or $6.00 per kilogram, as was the case in 1910. At present the cost of rubber is about $2.00 per kilogram or nearly $1.00 per pound. Synthetic rubber costs a little more.

Another great service which the chemist has rendered to the rubber industry is the preparation of "reclaimed rubber." Modern methods of treating worn-out articles chemically, so as to destroy the foreign substances contained therein, have resulted in yielding a product that compares very favorably with the pure, crude rubber and it is quite generally used in the manufacture of rubber articles. Here, however, there is room for improvement, and it is still left to the chemist to devise some way of extracting the sulfur from the reclaimed rubber.

What has been said in the preceding pages is by no means all that the chemist has done for the rubber industry. He has, moreover, discovered that zinc oxide toughens the rubber and increases its durability and tensile strength; that barium sulfate stiffens it and adds weight; that lithopone, a mixture of zinc sulfide and barium sulfate, whitens the rubber and makes it pliable; that antimony gives it a red color and is a preservative against oxidation; that litharge produces the same effect as antimony except that it makes the rubber black; but a coal-tar product known as MRX is chiefly used to blacken rubber; that white lead, aluminum silicate, magnesia oxide, and magnesia carbonate are good fillers and hasten the cure of rubber; that lime hastens vulcanization and removes any water left in the rubber which would cause blisters.

Each successive year witnesses improvements or new discoveries in the rubber industry all of which spring into existence from the magic hand of the wizard chemist.

THE INFLUENCE OF EARLY SCIENCE ON FORMATIVE ENGLISH

P. H. Hembdt, Albion College, Albion, Michigan

In this brief survey an attempt is made to show how in their struggle to express scientific truth the early scientists affected the English language. Of the debt we owe these early pioneers of experimentation for their effort to make our language a satisfactory vehicle of thought, little has been written or suggested. In recognition of this unusual service, this brief discussion is respectfully submitted by a professor of English in the hope that it will create still deeper respect in the scientists of today for their predecessors in the field of experimentation. Roughly speaking the three decades ending in the year 1675 give the chronology of this discussion.

While Oliver Cromwell was vanquishing the Royalists in the destructive Civil Wars, academic studies were seriously interrupted at Cambridge and Oxford. It was at this time that a small group of scholars residing in London found diversion from thoughts of war by holding weekly meetings to discuss science or what was then called the "New Philosophy," or the "Experimental Philosophy." The meetings flourished moderately during the Protectorate. Under the enthusiasm and inspiration of Dr. John Wilkins, afterwards Bishop of Chester, Dr. John Wallis, professor of geometry at Oxford, Dr. John Goddard, a botanist, and Robert Boyle, the noted chemist, others joined the group. Among the latter, worthy of special mention were Viscount Brouncker, Henry Oldenburg, and Robert Hooke.

Shortly after the death of Cromwell it became evident that Richard, his son, was unable to guide the destiny of England, During the unsettled months which ensued in the year 1659, the members of the "Invisible College," as the organization was called by Robert Boyle, were scattered to the four winds and their place of meeting was converted into barracks for soldiers. But with the return of Charles II in 1660 came peace. Now, the scattered members, especially those that had gone to Oxford, soon returned to take up their vocations in and about London. The weekly gatherings were revived and the society at London again held flourishing meetings in Gresham College. Sir Paul Neile, John Evelyn, Thomas Henshaw, and Dr. William Crowe were added to the enlarging group. In the autumn of 1660, when the college work was well under way and it became evident that Charles II had brought not only peace but also a united era of good feeling and prosperity, Sir Robert Moray, who had influence with the King, Christopher Wren, destined to become the architect of St. Paul's Cathedral, and other eminent men, "curious about every new discovering in science," joined the London enthusiasts. Charles II took active interest in the Society and witnessed the dissection of two human bodies on January 16, 1660, and on at least

two other occasions sent the Society problems for their consideration.

The workable principles of the "Invisible College" and the ideal "Philosophical College," of which John Evelyn wrote, were incorporated in the *Royal Charter of the Royal Society of London for the Improving of Natural Knowledge*. This charter was granted by Charles II on July 15, 1662. Throughout all these trying years the King continued to be solicitous about the welfare of the organization of which he proudly subscribed himself "Patron and Founder." In October following the incorporation, the King added further prestige to the Society by declaring that "no patent should be granted for any philosopical or mechanical invention until examined by the Society."

Interesting, indeed, it would be to enter into the problems and experiments undertaken by the Fellows while the Society was in its inchoate state, but that is beyond the scope of this paper. In the first years of the life of the Society, the experiments performed before the Fellows were carefully transcribed in the Society's Journal-Book, which was closed up and kept under lock and key against the next Wednesday meeting. This secretive nature, however, soon disappeared, for shortly after the beginning of the chartered life of the institution, manuscripts were reviewed, and, if found worthy of the distinction, were published "By the Order of the Royal Society." A further step in the dissemination of scientific knowledge was taken early in 1665 when the Council approved the plan of the secretary, Henry Oldenburg, to publish the results of the weightier experiments. This decision is responsible for the establishment of the *Philosophical Transactions*, March, 1665, as the official publication of the Royal Society.

The French issue of *Le Journal des Scavans*, to be sure, antedates the *Philosophical Transactions* by a few months, but Oldenburg did not copy its style nor form. The printed page of the *Journal* is one and three-quarters by three and three-quarters inches, non-pareil type—nothing in execution like the modern magazine. The first number of the *Philosophical Transactions*, however, had the good fortune to hit on a quarto sheet; and its pica type occupied six and one-half by four and one-quarter inches—the approximate size of that of the present-day monthly magazine. Its pages were open alike to representatives of "the commonwealth of learning" and to the dilettanti. The only prerequisite, the only shibboleth imperative to all alike, was that the message be conducive of the promulgation of natural knowledge and it be written "free from the colours of Rhetorick, the devices of Fancy, or the delightful deceit of Fables." Hence we find communications, epitomes, and papers from unliterary and unpretentious sources side by side with the formal letter, which is in reality an essay and the formal "observation" (the precursor of the modern magazine article) of the literary, the ingenious,

and the curious. The practicability of the scientist was in evidence early for we find an extract containing "some observations made in the ordering of Silkworms made by one Mr. Edward Digges from the remote country of Virginia." The issue dispensing these important items contains also an analysis of the "Experimental History of Cold" by "that Noble Philosopher," Mr. Robert Boyle.

To the Royal Society, Sir Isaac Newton communicated all his discoveries. The first mention of Anthony Van Leeweenhoeck of Delft, the "Father of Microsopical Discoveries," was made in the *Philosophical Transactions*. John Wilkins, Dean of Chester, John Wallis, Savilian professor of mathematics at Oxford, Robert Hooke, professor of geometry in Gresham College, Edmund Halley, the Royal astronomer, John Evelyn, Christopher Wren, Francis Willoughby, Viscount Brouncker, and Nehemiah Grew were early prominent contributors whose names gave tone and weight to the undertaking. After a few issues of the *Philosophical Transactions* had appeared this magazine was regarded as the best scholarly publication in Europe. "As early as 1669 the importance of the *Transactions* abroad was attested to by a translation into Latin at Copenhagen and printed at Franckfurt on the Main in 1671." Election to membership in the Royal Society, with the coveted privilege of writing F.R.S. after one's name, was recognized as a badge of very high distinction.

A group of scholars such as these early Fellows, chosen from Europe and America, with a burning passion to advance science, became a power for any cause which they agreed to espouse. The one stumbling block which the Fellows discovered lay in their way, when they attempted to put their experiments in writing, was the current style of the English language. Sir Thomas Browne, a physician of Norwich, author of "Hydriotaphia," and the "Gardens of Cyrus" and Richard Burton, who "pillaged Minerva's tower" to acquire the learning displayed in "The Anatomy of Melancholy," did more than any other writers to crystallize the style of expression at the time of the Restoration. Their sentences were long and involved and contained many allusions to obscure events in the Bible, mythology, and "unnatural natural history," after the fashion of Pliny. Their diction was highly latinized and their words connoted one thing in one sentence and occasionally something else in another. Certainly such language is no adequate vehicle of thought for the scientist.

In 1667 Thomas Sprat, Bishop of Rochester, published his "History of the Royal Society of London" in which the matter and the manner of the style that the Fellows adopted in their communications and experiments are given. Here are a few statements taken from this book:

> Their [the Fellows] purpose is, in short, to make faithful Records of all the works of Nature, or Art, which can come within their reach: that so the present age, and

posterity, may be able to put a mark on the Errors, which have been strengthened by long prescription: to push on those which are already known to more various uses: and to make the way more passable to which remains unrevealed. This is the compass of their design. And to accomplish this, they have indeavor'd, to separate the knowledge of Nature from the colours of Rhetorick, the devices of Fancy, or the delightful deceit of Fables.

That the Bishop of Rochester was alluding to the romantic and the imaginative element so prominent in the diction of Sir Thomas Browne, is evident. Nor need one look for any other allusion in "the delightful deceits of Fables" than to Burton and his admirers. Evidently another pattern was now to set the fashion. To quote again:

The manner of their [the Fellows] discourse which, unless they had been very watchful to keep in due temper, the whole spirit and vigor of their Design had been soon eaten out, by the luxury and redundance of speech.

The following paragraph refers to the action taken by the Fellows while the Society was in its incipient state, a decade or so before its final incorporation:

They [the Fellows] have therefore been most vigorous in putting in execution the only Remedy that can be found for this extravagance: and that has been a constant Resolution to reject all the amplifications, digressions and swellings of style: to return back to the primitive purity, and shortness, when men deliver'd so many things, almost in an equal number of words. They have exacted from their members, a close, naked, natural way of speaking; positive expressions; clear senses; a native easiness; bringing all things as near the Mathematical plainness as they can: and preferring the language of Artizans, Countrymen, and Merchants before that of Wits and Scholars.

These prescribed limitations of expression were carefully considered before scientists ventured to put their thoughts upon paper. The manifesto worked like magic, for Sprat's command had not fallen on deaf ears. Hence to the early scientists we are indebted for a simpler English sentence freed from circumlocutions and rhetorical embellishments.

The Fellows insisted on plainness of expression. This resulted in a much shortened sentence. Within a decade after the incorporation of the Society, their own sentences were reduced from an average of 61 words to a little less than one-half that length. Some of the younger writers had periods averaging so low as 24 words. Macaulay, who came nearly two hundred years later, is generally called the father of the modern sentence, and perhaps rightly so; but were it not for his unusually short topic sentences, Macaulay's average, however, would run on far beyond that of these early Fellows. Dryden, who was at the zenith of his ability in 1675 certainly did exceed the Fellows, but being himself a Fellow of the Royal Society he, no doubt, obeyed the cry to hold to a more simplified sentence. In fact a committee of which John Wilkins was Chairman was appointed to consider the improvement of "our English tongue." John

Dryden, the greatest literary man of the age, was a member of that committee and was probably influenced by its discussions. However, his sentences soon were perceptibly shortened.

John Wallis was the first of the Fellows to carry "mathematical plainness" from the word to the sentence and the paragraph. His language was largely influenced by his mode of thinking. Being a geometrician, he defines his terms and calls to his assistance the drawing or diagram. This method insists on a short, terse sentence stating at the outset what is to be established. Wallis then proceeds to prove this proposition, or statement, in a few clear sentences and at the sacrifice of literary adornment. To Wallis must be given the credit of building up the paragraph with a topic-sentence, proof, and a conclusion. Indeed, the traditional "Q. E. D." of the geometrician might appropriately close his argument. Wallis was a popular man, well-known throughout England, and his method of paragraph building attracted the attention of the literary men of his age, and established the fashion in which a virile paragraph might well be developed, a worthwhile contribution to the expression of thought.

When the *Philosophical Transactions* published Isaac Newton's *Theory of Light*, the author was immediately attacked by Hooke of London; by Pardies, a Jesuit professor of mathematics in the College of Clermont; by Linus, a physician of Liege; and by Huygens of Leyden and Breda. All impugned the accuracy of his theory. Although Newton emerged the victor from these attacks, yet he had been cut to the quick by their acrimonious tone. At this time he wrote Henry Oldenburg, the Secretary of the Royal Society: "I intended to be no further solicitous about matters of Philosophy; and therefore I hope you will not take it ill, if you find me never doing anything more in that kind." Fortunate, indeed, was it for science that such a body as the Royal Society existed, to whom Newton could make his scientific communications; otherwise, it is quite possible that the *Principia* would never have seen the light. That he did not withdraw from the world is positive evidence of the significance of the Royal Society in the development of thought in Europe.

Like Wallis, Newton gets his compass set before he puts his ship to sea; but he is unlike Wallis in that his scientific prose is flexible. They both struggled to express the growing national temper of England to search out and to set forth clearly indisputable truth. Being mathematicians, both held to a strictly mathematical method of development, but with Newton the diagram is not so imperative. Sir Isaac is not so sparing in words as Wallis or Brouncker; indeed, he often interpolates an adverb or some idiomatic expression which gives such an easy naturalness to his style that one almost forgets the iron logic which is beneath the easy flowing thought; but he is never prolix. He knows exactly what he wants to tell and often isolates his proposition in the left-hand

margin of the page at the beginning of the paragraph, better to show the point to be established. That Newton would make his style of expression conform to the mandates agreed upon by the Society is evident. His contribution to formative style lies in raising the paragraph and the theme to a "mathematical plainness"—an item which was not exactly "so nominated in the bond." Newton took the beginning of the paragraph as it issued from the mathematical method of Wallis, gave it more definiteness of structure, and sustained it to the end by the coherence of his thought and by the use of suitable connectives. His concluding sentence of the paragraph is generally of the nature of a summary.

The periods of Newton, as they appear in the *Philosophical Transactions* for the year 1673, are all short. The average length of his sentences for this time is 32.13 words—a sentence somewhat longer than Macaulay's but only two-thirds the length of Dryden's. An examination of Newton's paragraphs shows that their virility rests on a mastery of two things; first, unified subject-matter and, second, a careful articulation of the sentence through the proper use of conjunctions. "For," "but," "therefore," "consequently," "because," "accordingly" are in evidence on almost every page of this author, and these connectives bind his paragraphs into a coherent unit. Many other prominent scientists followed Wallis and Newton in the structure of the sentence and the arrangement of the paragraph. A new style of expression was developed by these prominent scientists and this style became established by their imitators until it became the form also for the wits of the time and passed into literary prose.

What influence has early science played in the development of formative English? It, through the *Philosophical Transactions*, gave rise to the monthly magazine, establishing its monthly appearance, size, form, and type. The *Philosophical Transactions* hold a unique place in the history of journalism. There had been nothing like it in mechanical make-up; no other periodical of Europe had been so favored by the government, so encouraged by the King; no other had such weighty matter discussed by great men. Its circulation was large and constantly growing. It was published in English when European scholars requested it to be put into the scholarly Latin. Even Francis Bacon and Richard Burton, it will be recalled, had no faith in the permanency of the English language for the former had his works translated into Latin and the latter deprecated the growing popularity of his native tongue. The early scientists had abundant faith in their native tongue. They, through the publication of the *Philosophical Transactions*, dignified the English language and put it on equality with the great tongues of Europe. They shortened the sentence and made it clear and exact. They developed a coherent paragraph and a coherent theme. They put an end to "the delightful

deceits of Fables" as Sprat characterized the style of Sir Thomas Browne. And the style of Richard Burton, who for literary effect "pillaged antiquity" to heighten his hypochondria, became obsolete. All these things and more, too, were accomplished in three decades by the early English scientists in the establishment of modern prose. A worthy heritage!

Smallest Particles Said to Surround Electrons. That particles even smaller than the electrons, hitherto supposed to be the smallest things in the world, surround the parts of which atoms are built up, and that this hypothesis may reconcile the old wave theory of light and the newer "quantum" theory, is the suggestion made by Sir Joseph Thomson, considered the leader of British physicists. This was made in his recent Kelvin lecture before the Institution of Electrical Engineers. According to modern notions, an atom consists of a central, rather massive nucleus charged with positive electricity called a proton, surrounded at relatively great distances by ultra-minute particles of negative electricity called electrons, which rotate in different orbits around the nucleus.

In order to reconcile the modern view that energy is emitted in small separate bundles or "quanta," with the older ideas, Sir Joseph said, it is necessary to assume that both the proton and its satellite electrons are surrounded by an atmosphere of much smaller particles, the impact of which on the protons and electrons causes them to vibrate and send out energy. "Both proton and electron must be regarded as nebular systems," he stated.

Theory indicates that the vibrations or oscillatory movements of protons and electrons should give rise to electrical waves, and Sir Joseph believes that such waves are actually produced, although ordinarily they are unable to escape from the outer confines of the atom, being reflected back into the interior. The so-called "quanta" of light he believes to consist of bundles of electrical waves shot out from the atom at the same time as ordinary electro-magnetic waves.—*Science Service*

Malaria in Palestine Yields to Paris Green. Malaria in the Holy Land is giving way before onslaughts on the mosquito. The Malaria Commission of the Health Organization of the League of Nations attributes the high degree of success in its anti-malarial campaign in Palestine very largely to its efforts in exterminating the fever-bearing mosquito larvae.

Swamp draining and oiling and Paris green have been the principal agents of death to the young wigglers in the intensive war which has been waged by the commission since 1918 when the malarial incidence, even under normal circumstances bad enough, ran unusually high, due to the unsettled abnormal conditions brought about by the war.

Quinine treatment of school children and a general return to more normal conditions have all contributed to the current decline of the disease but anti-larval measures have been the chief factors according to the Malarial Commission's report to the League of Nations.

The International Health Board of the Rockefeller Foundation and various Jewish organizations have been of great assistance in the general process of putting into practice the engineering feat of ditching and oiling Palestine, Prof. N. L. Swelengrebel, of the medical faculty of the University of Amsterdam and member of the Commission, declares.—*Science Service*

A NEW PERIODIC TABLE OF THE ELEMENTS*

C. J. MONROE AND W. D. TURNER, MISSOURI SCHOOL OF MINES, ROLLA, MISSOURI

Introduction

Historical Review.—In 1871 appeared Mendeléeff's memorable paper entitled "The Periodic Regularity of the Elements." Since then many modifications have been proposed, intended to depict more clearly the true relationship of the elements, and recently with a knowledge of isotopes and atomic numbers, these tables have approached completion so far as the known range of atoms extends.

All these tables have certain disadvantages, either because elements of dissimilar character must be placed in the same column, due to lack of sufficient columns, or an unavoidable break must be made at the end of a line in order to start another line in the same table, or blanks are left for which there are no atomic numbers, or the placing of elements such as the rare earths is dodged entirely.

The Modern Conception.—In the modern idea of atomic structure, the atom is conceived as having a compact positive nucleus encircled by a number of electrons equal to its atomic number. These electrons are arranged in orbits which cannot exceed in size, respectively, outward 2—8—18—32—18—8—?, incomplete knowledge of the seventh series rendering the data on the fifth and sixth orbits somewhat uncertain. The valence of the element is dependent on the electrons in the outside orbit which never exceeds eight.

With the progressive increase in the number of electrons in any orbit, there are found among the resulting elements electronic configurations which repeat the characteristics of those formed in the building up of the previous orbit. Hence, the elements may be classified into periods according to the number of electronic orbits in the atom. The purpose of the new table is to employ this information in eliminating as far as possible the disadvantages of former tables.

Description of the Table

Basis.—To depict in sheet form a number of series of varying length, while retaining the elementary family groups, will necessitate a break in the continuity from line to line so as to bring the elements into columns. Such an arbitrary break is, of course, not indicated with a continuous spiral and the advantage is gained that one period follows another in continuous progression without the necessity of any artificial discontinuities. An example of the application of this advantage is found in Harkins' Space Table, and a similar structure has been devised for the new table.

* Read Dec. 30, 1925, before Section C of the American Association for the Advancement of Science.

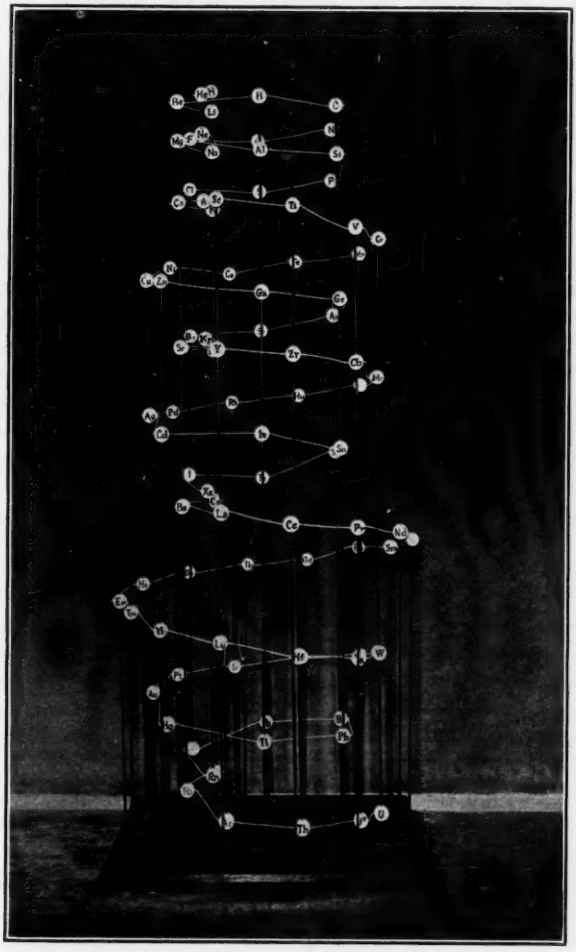


FIG. 1.—Space Periodic Table.

Consisting of four concentric circular loops of two, six, ten, and fourteen rods, respectively.

On the loop of two are the alkalis and inert gases, those elements in the building up of which the added electron is found completing an outer orbit or starting a new one. On the loop of six are the remaining elements in the building up of which the added electron is found in the outer or valence ring. These two loops contain the well-known octaves which formed the basis of all early tables.

On the loop of ten are those elements in the building up of which the added electron is found in the second orbit inward. This loop, in conjunction with the two inner loops, holds the eighteen element periods. On the loop of fourteen are those elements, the true rare earths, in the building up of which the added electron is found in the third orbit inward. This loop in conjunction with the others holds the thirty-two element period.

Constructional Detail.—A photograph of the model is reproduced herewith and indicates the method of mechanical construction. A wooden base is used in which are placed rods to support the various families. On these rods are placed white enameled discs, one for each element, carrying on one face its symbol, atomic number, and atomic weight and, on the other, its electronic orbits. These discs are placed at a distance downward from the top proportional to the international atomic weights. No attempt is made to indicate the isotopes of the elements.

Arrangement of the Table

Loop of Two.—The first prominent departure of this from previous tables is in the treatment of the first series of two elements, hydrogen and helium. These are treated as a complete period depicted on an inner loop of two rods, a simple procedure, yet clearly justified by the recurrence of the same electronic configuration at the start of the next period after this short involution. On this loop are those elements in the building up of which the added electron is found completing an outer orbit or starting a new one.

Loop of Six.—The next two periods contain the well-known octaves which formed the basis of all early tables, but since these two periods contain elements repeating the characteristics of the previous short period, a loop of six added around the inner loop of two will suffice for the entire octaves. On this loop are the remaining elements in the building up of which the added electron is found in the outer or valence ring. It will be noted that this arrangement throws the alkalis naturally with hydrogen, thus clearly indicating their similarity of electronic structure.

Loop of Ten.—The next two periods are called long periods in the Mendeléeff table and represent the four-orbit and five-orbit elements. These periods each contain eighteen elements and, therefore, require a loop of ten around the already provided loops of two and six, since the characteristics of the elements of the inner loops are repeated in each of these periods. On this loop are those elements in the building up of which the added electron is found in the second orbit inward.

It may be noted that this arrangement leaves calcium, etc., under beryllium and magnesium where it belongs by structure, providing another position for zinc, etc., showing its distinction from them. The same is true also of gadolinium and scandium and other so-called double groups. It may be observed further that the main body of this loop, beginning with titanium, contains elements of similar property, this similarity becoming increasingly apparent through nickel towards the end of the loop.

Loop of Fourteen.—The next period in the Mendeléeff table, including the six-orbit elements, contains the rare earths, making a total of thirty-

two and, therefore, requires a loop of fourteen around the previous loops of two, six, and ten. The elements in this outer loop may be called the true rare earths. (The first position of this loop would indicate that the element cerium should be expected to exhibit some properties as if it were under zirconium on the loop next inside.) It may be noted that this arrangement places the rare earths in individual positions, distinct from the remaining families and distinct from each other. On this loop are those elements in the building up of which the added electron is found on the third orbit inward.

The Last Three Elements.—The last period in the Mendeléeff table containing seven-orbit elements is incomplete and data are, therefore, lacking on which to determine unquestionably whether this is the beginning of an eighteen or a thirty-two element series, or, speaking electronically, whether additional electrons would build into the second or third orbit inward. In this table they are placed on the loop of ten in a position which would indicate the tendency of added electrons to be found in the second ring. In either case, thorium exhibits chemical properties similar to zirconium and cerium; uranium X has never been assigned a complete set of chemical properties, while uranium, with its colored ions and other chemical properties, would not be out of place under chromium. Their position on the loop of ten is, therefore, assigned on the basis of chemical properties rather than on symmetry of the table, which would be improved by placing them in the outside loop in accordance with Rydberg's views. This procedure is adopted on the spiral projection.

Discussion

Valence Indications.—The new arrangement of the table portrays a number of important features, among which the valence indications may be considered briefly.

On the inside loop of two are found elements which exhibit no tendency for an electron to transfer to the outside or valence loop, either from an internal or external source, with the unique exception of hydrogen whose outer ring is built up to the fundamental complete orbit of two by the acquiring of a single electron, as in the formation of hydrides.

On the loop of six will be found elements which exhibit no tendency for an electron to transfer to the valence orbit from an internal source and among these are the only elements which exhibit a tendency to acquire such electrons from an outside source, thus producing a negative valence. This tendency increases among the elements with progress around the loop from none on the first rod to all on the last.

On the loop of ten will be found those elements which exhibit a tendency for one or more electrons to transfer to the valence orbit from the next or second orbit inward, this tendency increasing with progress around

the loop from one, on the first rod (containing scandium, etc.), to six on the sixth (containing osmium, etc.), and disappearing toward the end of the loop. These electrons may vibrate between the two orbits, due to the relatively slight difference between the forces holding them in either

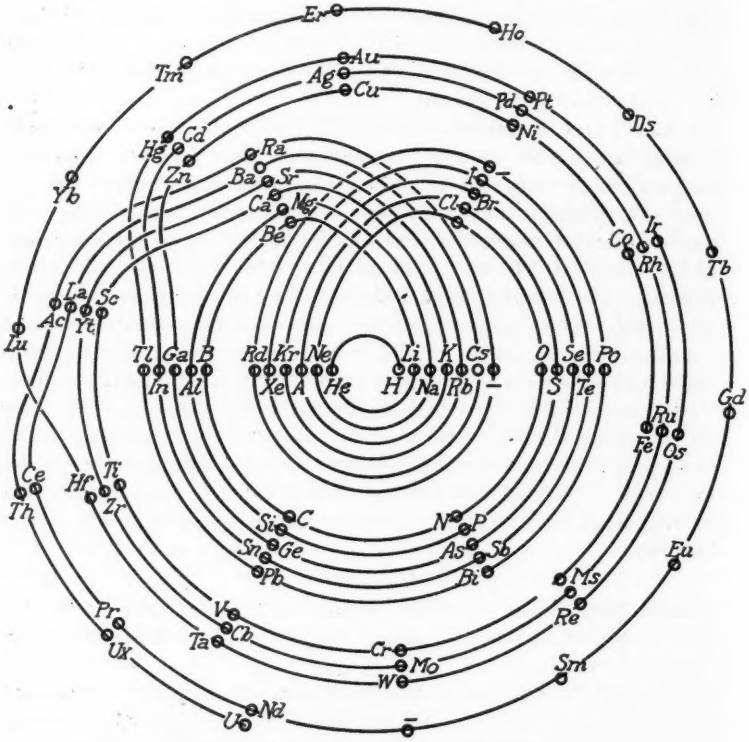


FIG. 2.—Circular Periodic Table.

A base projection of the space model with the same inherent characteristics.
On the inside loop are elements which, with the exception of hydrogen, exhibit no tendency for an electron to transfer to the valence loop, either from an internal or external source. On the loop of six are elements which similarly exhibit no tendency from an internal source but among them are the elements which exhibit this tendency from an outside source, thus acquiring a negative valence. On loop of ten are those elements which exhibit a tendency for one or more electrons to transfer to the valence orbit from the next orbit inward, hence, in general, their positive valences will be found variable and their ions colored. On the loop of fourteen are those elements which exhibit a similar tendency from the third orbit inward thereby producing a positive valence of three (four for cerium).

orbit, hence in general their positive valencies will be found variable and their ions will be found colored.

On the loop of fourteen are those elements which exhibit a tendency for one electron (two in the case of the first element, cerium) to transfer to the outer orbit of two from the second or third orbit inward, a tendency so

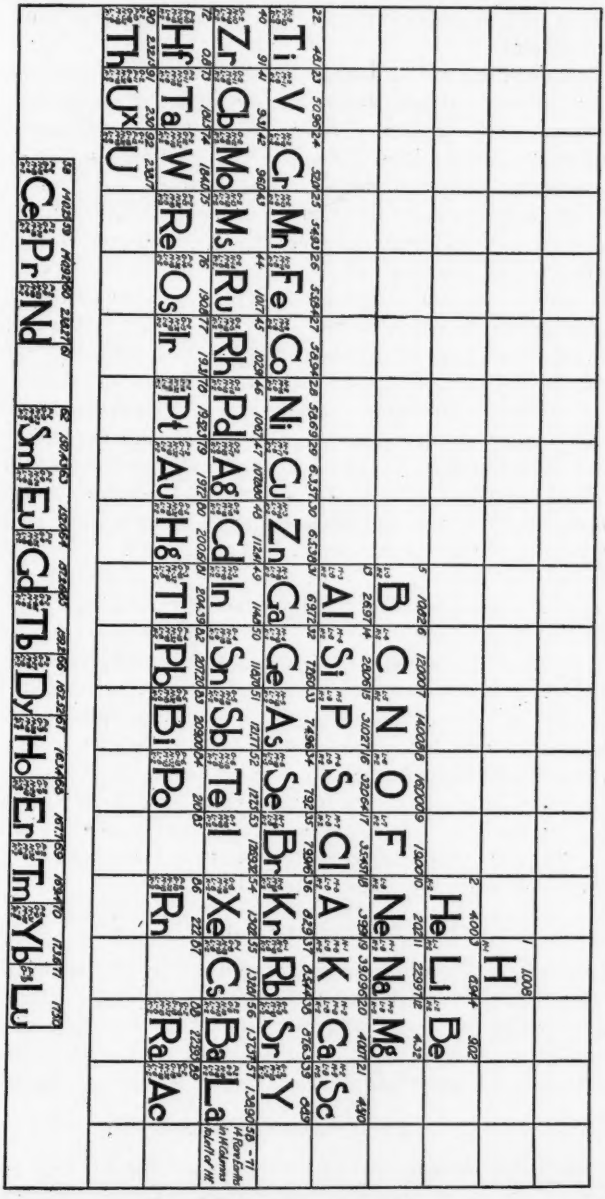


FIG. 3.—Chart Periodic Table.

Developed from the space model by breaking the continuity from line to line at hydrogen, beryllium, magnesium, scandium, yttrium, lanthanum, and actinium.

This table places hydrogen with the alkalis but is so designed as to present its arrangement also, if preferred, with the halogens, thus indicating its dual relationship.

pronounced that in general only a valence of three is found among any of their compounds.

The End Positions of the Loops.—Another feature of the table is the significance of the end positions of the loops. Here are found the elements which exhibit properties in common with those of their own and with the next adjacent loop. Thus at the start of the outer loop is found cerium, which by the transfer of two electrons to the valence orbit, instead of one, is enabled to exhibit properties like zirconium. At the end of this loop is found lutecium which might be expected also to possess anomalous valence possibilities.

At the start of the next adjacent loop of ten will be found the scandium group elements exhibiting properties similar to the rare earths with which they are usually classified. At the end of this loop are found the copper and zinc groups which are of particular interest in that of all the elements on the loop, they alone exhibit a valence of one. This is explained in the case of the copper group elements as due to the tendency of one of the valence electrons to drop into the next inner orbit completing the stable number of eighteen and, in the case of mercury and cadmium, to the greater relative distance between the outer electrons as indicated in their low melting points and the slight ionization of their salts.

At the start of the loop of six are found the alkaline earths which, as previously indicated, act like the inner loop elements in exhibiting no tendency to become electro-negative by acquiring electrons from an external source. At the start of the loop of two is found hydrogen whose valence possibilities, mentioned above, are due to the fact that its valence orbit contains one electron, so classifying it with the alkalis, yet this orbit will be completed by the acquisition of one electron from an external source, thus rendering it similar also to the halogens.

At the ends of the loops will be found the elements of minimum melting point for the loop as far as conclusive data are available. The melting points of the rare earth elements are uncertain, though their chlorides seem to give a minimum at the middle of the loop.

The Circular Table

The base projection of the space arrangement gives a two-dimensional table, in circular form (shown in Figure 2), with the same inherent characteristics as the model. In this table the last three elements are placed on the outside loop in accordance with Rydberg's views and in contradistinction to their positions as adopted in the space model.

Two-Dimensional Chart

To make the new table available as far as possible in chart form, the arrangement shown in Figure 3 was devised. This is developed from

the space model by breaking the continuity from line to line at those elements which stand at the start of the various loops. Thus hydrogen is at the start of the loop of two and represents the first break, but lithium is followed by beryllium at the start of the next loop of six, hence the break here follows the latter. This table places hydrogen with the alkalis but is so designed as to present its arrangement also, if preferred, with the halogens, thus indicating its dual relationship.

Summary

I. A new space model periodic table has been devised which has the elements arranged on loops of two, six, ten, and fourteen. Differences in the valence characteristics of the elements on the various loops, the importance of the end positions, and the anomalous behavior of various elements are indicated by their positions in the new table.

II. By a base projection of the space model, a spiral table has been prepared possessing many of the advantages of the space model.

III. A periodic chart with breaks for the ends of the horizontal lines at H, Be, Mg, Sc, Y, La, and Ac has been devised.

Muscle Building Protein Poisonous in Blood. Injection of protein in the blood stream will produce poisoning. Protein poisoning has been brought about artificially by injection of bacteria and bacterial toxins, and comparatively recently a Polish doctor working in Germany produced the same effect by injecting a protein compound. Dr. Richard H. Jaffe, of Chicago, has been carrying out a series of experiments of the same sort on mice and gives an account of his results in a paper in an issue of *Archives of Pathology* shortly to be published.

To the lay mind it seems strange that compounds of protein, which is the essential element of such foods as meat and milk necessary to build up human muscle tissue, should cause such havoc when introduced in the circulatory system. This is partly explained by the fact that all proteins are very difficult to dissolve. Dr. Jaffe found that the poisoning, which is known medically as amyloid degeneration, is at first very gradual but after long-continued injections becomes very severe and eventually causes death. He explains this effect as due to an acquired hypersensitiveness on the part of the animals to the injected substance.—*Science Service*

Missing Elements Sought in Water of Dead Sea. The Dead Sea is the latest locale of the search for the two elements still missing from the chemist's periodic table.

The high concentration of salts in this famous body of water caused J. Newton Friend of the Municipal Technical School of Birmingham to consider the possibility of their containing either eka-caesium or eka-iodine, the names assigned to the elusive elements.

Diffractionations of samples of the water were accordingly carried out and the final diffractionation products submitted to X-ray analysis but, unfortunately, the spectrum lines that would reveal the presence of either the one or the other failed to show up. Traces of the element strontium, however, were found, the presence of which had never been recorded in any previous analyses of Dead Sea water.—*Science Service*

THE FIRST LECTURE IN GENERAL CHEMISTRY*

A. T. BAWDEN, OTTAWA UNIVERSITY, OTTAWA, KANSAS

Sufficient attention is seldom given to the importance of the first lecture in general chemistry, partly because this lecture occurs at a very busy time for the teacher. It is needless to tell a teacher that the impressions gained by the student at this first meeting will determine to a large measure the success that the teacher or student will later achieve in the course. This paper deals with the situation that exists at the first meeting and gives some suggestions as to the content of the first lecture in college general chemistry. The object of this lecture is to put the student into the right frame of mind for future work. The material given is based on experience in teaching in a small university and would not have complete application in the larger universities, especially state institutions, where different problems are presented.

The lecture opens with an announcement of a policy of fair dealing and a desire to understand the student's point of view. We next state that our purpose is to teach chemistry in the best way that we know how to do it, and that we assume that our students want to receive as thorough a course as is given in the country. At this point brief mention is made of the texts used and why they were chosen.

We next discuss the attitude of the different students as they first enter the college chemistry lecture-room. This attitude depends upon the students' former experience with chemistry. At this point ten minutes or more spent on the subject, "What chemistry is, how important it is, and why?" should prove to be quite valuable for the student who has never studied chemistry. Slosson, in his introduction to "Slosson's Smith's Intermediate Chemistry" expresses the thoughts which should be brought out at this point.

A second type of student has had a course in high-school chemistry. As a general rule the small school cannot offer a more advanced course for such students, so they must be put in with students who have no knowledge of chemistry. Among these students there will be those who received a high grade in high-school chemistry, and as a result enter the lecture room for the first time with a know-it-all attitude. Any teacher who has encountered such an attitude on the part of the student, realizes that although the student's interest in the subject may already have been established, no progress can be made until the student can be made to forget that he ever had any chemistry. These students should be warned that often high-school chemistry acts as an anti-toxin, inoculating the students against further attacks. We have seen a number of such students drop the course on account of low grades because they considered it

* Paper read before the Division of Chemical Education of the A. C. S. at Tulsa, April 7, 1926.

unnecessary to study for the first few weeks. We tell the class about this experience.

The third type of student did not do so well in high-school chemistry, due to poor teaching, lack of interest or ambition, or some such reason. Chemistry was "awful hard for her." The word "her" is used advisedly, because this attitude is found more often among the young women. In all probability this student would not be enrolled for chemistry if it were not a prerequisite to some other course.

Such a student must be shown that chemistry is romantic as well as practical, and that the subject is not "hard" when properly taught and studied. It should be pointed out that chemistry must be studied in a different way from that employed in mastering an English, French, or history lesson.

A fourth type of student, be he upper-classman or freshman, has come to the lecture room scared nearly stiff. He has known or heard about many students who "flunked" chemistry, but has not known the reasons, which may usually be boiled down to lack of application. He or she has heard of the long laboratory periods. Perhaps he has heard that a chemistry lesson cannot be mastered in less than two hours. He may even have seen some complicated organic structural formula on the blackboard some time. At any rate, this student knows that chemistry is *hard*. He is serious and he is scared. He doubts his ability to do anything in chemistry. If such an attitude is allowed to remain in the student's mind, then, at every difficulty, he will say, "This is too hard for me. I am just naturally dumb in chemistry." Such a student must be shown that chemistry need not be hard, but that it can be made so.

We quote here from a paper turned in at the first meeting of the general chemistry class on the previously assigned topic, "What I expect to learn in chemistry." It is a good example of the attitude of some of the students.

"I do not expect to learn much from chemistry. I will not retain half of what I learn. However, I do expect to learn everything that is necessary to home economics. Chemistry does not interest me. In fact it will be difficult for me because I have not the power to reason anything out. I know I shall have to study but I could study forever on such things and not learn anything much. I do expect, at least, to learn about chemicals, but I do not expect to retain it."

Fortunately our first lecture fitted the needs of this student and a private conversation with this girl after the class revealed that her attitude had been entirely changed. We try to help such students by the use of the following material.

"Some of you think that chemistry is hard. You came here today prepared to learn just what it would be, but you were sure that it would

be hard. That is the first idea that I must eliminate before I try to give you any others. If you have sufficient ability to obtain a college degree you have sufficient ability to pass a chemistry course creditably.

"Why is chemistry any different from other subjects, and where is the difference? Well, what is education? We venture to add to the long list of definitions already existent and state that it is learning to put old ideas together to form new combinations. Now, for some subjects the work is largely that of combining the facts and knowledge that we already have to form new ideas. In chemistry we do this also, but there are a few facts which we must first master. In freshman chemistry these facts are first presented. It takes time to master the facts, so that time is an element necessary for success in this course. The advanced courses in chemistry are largely devoted to putting these facts into different interesting combinations. This is the enjoyable part of the study, and the quicker you store up some facts and begin to use them in answering new questions the quicker the course will become a pleasure to you.

"There is a certain knack about mastering these facts. Some people require much more time than others, because they have not learned how this is done most efficiently. One person learns more facts than the other does and of course it takes more time. The process of cutting down on the number of facts which are to be learned is called generalization, and I am going to give you some practice in this method of studying this semester. It will prove invaluable to you whenever you have a large number of facts to learn.

"As I have shown, the nature of the subject demands more time than some others, but otherwise it is not hard. Chemistry will be easy for everyone who unfailingly puts at least one to two hours of intelligent study each day on the preparation of their lessons. I guarantee this. I also promise you that it will be hard, awfully hard, for anyone who does not give this much time to his chemistry lessons, and this must be done at the start. If you wait a month, and then begin to put this amount of time on the work it will still be hard, and always will be hard, because you have missed a few facts. You have not given yourself the straw with which to make your bricks; consequently the product will not be so good and will require more time to put it together, because you have to use poor materials or do without a few of them.

"If there is anyone who is spending the required amount of time on his lessons and is not learning the facts and is not able to generalize, then it is because he does not understand the process. I really believe that I can show anyone of you how to study chemistry if you will just come to me. I will gladly give you several hours' extra time if necessary, because I am here to teach you chemistry whether I do it in the class-room or out of it."

A fifth type of student has registered for chemistry only in order to fill some group requirement or for its cultural value. He never expects to use his chemistry. Possibly he would like to know something about it, but he is not going to try to get a thorough working knowledge of general chemistry. He is opposed to quizzes and examinations and is content to get what little he can by listening to the lectures and recitations. He prefers the role of an onlooker. He will do just enough of the required work to pass the course and will leave out what does not interest him. This student believes that there must be many things which a chemistry major is required to learn which would never be of any use to him and he knows that it is up to him to make the decision as to the selection of topics for his own use. It is a question in the writer's mind whether such a student should be allowed to enter a course with this purpose in view. And yet the writer realizes that there are such students, who have definitely planned their life work and are as sure, as it is possible for them to be, that general chemistry will be their only course in chemistry. One has some respect for these students because they enter the course thinking that it will not be altogether interesting to them, but still believing that their education is not complete without some rudimentary knowledge of chemistry. It is the writer's conviction that, where possible, a special cultural course in chemistry should be given to such students, in which the *how* is stressed quite as much as the *why*. Many teachers in small schools do not have the time to offer such a special course, or may not have sufficient demand for it to justify the time and expense involved, so these students are put in with the rest. The teacher does not want the class to be held back by these students, so he must try to show them, in his first lecture, that besides learning many useful facts and laws of nature the student may learn to study and to think, using chemistry as a medium. It must be shown that chemistry has advantages as such a medium and offers problems similar in their aspects to those which will be encountered throughout life. It will be well to discuss the place of interest in success, pointing out that interest seldom becomes real before it has been tried with hard work, and that interest develops in almost any work into which we are entering whole-heartedly.

A glimpse of the method by which the teacher hopes to accomplish these results should be given to the student at the first lecture, or at the second meeting of the class if there is insufficient time for it at the first meeting. Every student is eager to know how the course is to be conducted. After the first lecture the average student will be able to tell you about what proportion of his time he expects chemistry to take. The student wants to know what system of grading is to be used. The majority of students consider that good grades are worthy of a moderate amount of effort, but they are not going to work for grades unless they

know that the fruits are to be something more than the increased knowledge of the subject. Men do not need to tell them that this should be the only goal. They know that high grades mean honors, scholarships, pleased parents, and many other things. As long as colleges gage their students by their grades, just so long will a high grade be placed as one of the important considerations in the student's budget of time.

If a loose and unsystematic grading system is used, which depends largely on the judgment and sometimes personal likes and dislikes of the instructor, then the student will be discouraged and will put his effort into another course where he sees more chance of receiving a grade commensurate with his efforts. If, on the other hand, a systematic grading system is used he will be more apt to work even though the grades are based on accomplishment rather than what is attempted.

The teacher may take advantage of this attitude of the student towards grades and use the grading system not only as a method of determining the student's grasp of a subject, but also as a method of making the student work.

A future paper will deal with a grading system in general chemistry.

Madame Curie Favors International Scholarships. When the educational theories of Madame Curie, France's famous woman scientist, go into actual practice, the world may have more first-rate scientists and more real fundamental feeling of good will between nations.

In a report to the subcommittee on university relations, which will later be acted upon by the Committee on Intellectual Coöperation of the League of Nations, she advances some new suggestions for the training of embryo scientists. Closer coöperation between master and pupil with more freedom for the student to prove his real worth are points that Madame Curie stresses chiefly.

Since science has become so specialized, students must go to the particular places where they can obtain the best training for the subject in which they are interested, regardless of whether it is at home or abroad, she maintains. In recommending a system of national and international scholarships to meet this need, she advocates two kinds: one for the student who is just beginning his research work and the other for the advanced worker who may have already accomplished some research but who, without financial aid, would not be able to continue. The first is essentially, in her conception, an apprenticeship in which a student should work in groups of older, more experienced men until he has proved his value.

While she urges supervision and guidance of the student until he "finds himself," she would not hedge those who show real originality of mind too much about with the restrictions of academic red tape. "For," she says, "the exceptional mind is all too rare and should not suffer too much constraint."

Since this is an age of scientific development the need for more scientists is constantly growing. In consequence, declares Madame Curie, we need a more complete system of international scholarships and more endowed foundations both from governments and private donors to give adequate training to the world's scientific raw material regardless of the country in which it occurs.—*Science Service*

A QUALITATIVE ANALYSIS PUZZLE

CARL OTTO, UNIVERSITY OF MAINE, ORONO, MAINE

The puzzle given here is somewhat different from all standard types of puzzles. A good knowledge of the properties of the ions is required to solve it if no references to text-books are made. The idea is to identify ten unknown solutions by studying their reactions with each other. Thus a certain group of ten solutions of single simple inorganic compounds (A, B, C, –, –, –, –, –, –, J) was taken and mixed together in all possible combinations of pairs. The observations, as given in the following table at the junction of lines drawn from the letters representing the said solutions in the top and left margins, were noted. Thus, solution A added to solution B gave a yellow precipitate, soluble in HNO_3; solution A added to solution C gave a white precipitate, soluble in HNO_3, etc. Following the table are a few other observations which were noted. The problem is to identify the ten solutions from the data given.

	A	B	C	D	E	F	G	H	I
B	Yellow ppt. sol. in HNO_3								
C	White ppt. sol. in HNO_3	Red ppt. sol. in acids and NH_4OH							
D	White ppt. sol. in HNO_3	White ppt. sol. in acids	White ppt. sol. in NH_4OH						
E	Yellow ppt. sol. in HNO_3	Yellow ppt. sol. in HCl and HNO_3	White ppt. insol. in acids sol. in NH_4OH	White ppt. red solution ppt. sol. in acids					
F	Yellow ppt. sol. in HNO_3	Lemon-yellow ppt. sol. in acids	Yellow ppt. insol. in acids sol. in $Na_2S_2O_3$	White ppt. Soln. gives purple color with CCl_4	No ppt.				
G	White ppt. sol. in HNO_3	White ppt. sol. in acids	Red ppt. sol. in acids sol. in NH_4OH	Brown ppt. sol. in HCl	White ppt. sol. in acids	White ppt. sol. in HNO_3 and alkalis			
H	Black ppt. sol. in HNO_3	No ppt. If HCl is added white ppt.	Black ppt. insol. in acids except conc. H_2SO_4 or HNO_3	Dark green ppt. sol. in acids	No ppt.	White ppt. sol. in acids gas evol. turns $PbAc_2$ black	Yellow ppt. sol. in alkali sulfides		

	A	B	C	D	E	F	G	H	I
I	White ppt. sol. in HNO_3	White ppt. sol. in acids	White ppt. sol. in NH_4OH	Red-brown ppt. sol. in acids	White ppt. sol. in acids with evol. of CO_2	White ppt. sol. in acids	No ppt. slight effervescence	No ppt.	
J	White ppt. insol. in acids except conc. H_2SO_4	No ppt. orange solution	Slight ppt. sol. in NH_4OH Glass etched by fumes	2 gases evolved on htg. limewater milky combustible	White ppt. insol. in acids except conc. H_2SO_4	No ppt.	No reaction	White ppt. Colloidal Odor SO_2	Evol. of CO_2

ADDITIONAL DATA

All solutions are colorless except solutions B and D which are light yellow.
Solutions G, H, and J are acids.
Solution A gives the brown ring test.
Solution E gives a green flame test and solution I a yellow flame test.

(Answers to be published in the next issue.)

Iron Salt Recommended as Cure for Poison Ivy. Poison ivy meets its match in the iron compound known as ferric chloride, according to a new booklet on the toxic weed by Dr. James B. McNair, which is being issued by the Field Museum of Natural History. Dr. McNair discovered in the course of exhaustive researches on the chemical nature of ivy poison that this substance is rendered insoluble and thus made harmless by chemical union with iron. A number of soluble iron salts, he says, are effective against poison ivy, but he has found ferric chloride to be most suitable. His treatment calls for a mixture of one part by weight of ferric chloride with ten of alcohol and ten of water, to be washed on the skin and allowed to dry there before one goes into places where poison ivy grows, and also after such possible exposure. This, it is claimed, will entirely prevent the development of ivy poisoning in the great majority of cases.—*Science Service*

Franklin Institute to Honor X-Ray Tube Inventor. Invention of the type of X-ray tube now in almost universal use in hospitals and laboratories has won for Dr. W. D. Coolidge, assistant director of the General Electric Company's research laboratory, the Howard N. Potts Medal of the Franklin Institute.

This medal, of gold, will be awarded to Dr. Coolidge, says the citation, "in consideration of the originality and ingenuity shown in the development of a vacuum tube that has simplified and revolutionized the production of X-rays."—*Science Service*

American Competition in Glass Stimulates German Research. A new scientific institute has been founded in Berlin for the study of the physical and chemical problems underlying silica compounds and all the industries that use them, including glass factories, brick and tile yards, pottery works, lens laboratories, and many others. The advance of the silica industries in the United States based on American science during the past two decades is recognized as the stimulus of the new movement. In making its recommendation the committee said, "We in Germany have had to acknowledge to our cost that the Americans have known better than we how to carry out in practice the spirit of scientific advance."—*Science Service*

Chemical Digest

TRAINING THE CHEMIST

"Every one owes some of his time to the upbuilding of the profession to which he belongs" are the words of Theodore Roosevelt quoted by Dr. Treat B. Johnson in a recent article.[1] We, of the chemical profession, need to recognize the importance of the problems of chemical education. Dr. Johnson says that:

> Our interests are the universities' interests, and also the public interests, and we have a work of our own to do; and being engaged in a labor of science we owe a debt to our educational institutions, and consequently should be prepared to respond to their call for help and advice in their educational work. I feel quite certain (he says) that the men who are in active service in the teaching profession and in academic research activities do not disparage today the investigations done in industry, and do not put a low value upon industrial work and take a narrow viewpoint of chemical studies carried on successfully outside of the academic atmosphere. We are all working for the accomplishment of a definite object, and the closer we can coöperate in our various problems the more easily and quickly will we achieve the final results for which we all are striving.

It is expedient that we make this science of ours accessible to the public. Dr. William Blum[2] contends that:

> It is the duty of the scientist to translate, or have translated, the results of his research into terms that can be understood and, if need be, used by the layman. Much of the present interest in science is due to such splendid efforts as those of "Science Service," efforts which have shown that it is not necessary to employ highly specialized language to transmit the essentials of scientific truth. The work of the scientist is only half done when it is published in the annals of his profession; it must also be made available to all those who can use it. The world demands a living science, not a museum!.....
>
> The world expects great things of science; it expects science to "give new leases on life, and new tools and wider visions." The historian may recount the past, but cannot change it; the poet may paint the future, but cannot bring it to pass; the scientist alone can make his dreams come true. He cannot only harness the powers of Niagara, but can at the same time increase its grandeur; he can make the desert and the swamp alike fruitful; he can bring music and poetry through the air to the invalid. He cannot only meet the needs of humanity, he can also satisfy desires that science itself has created.

Regarding the remarkable advance made in educational work and methods during the past fifty years and the need for public recognition of the importance of chemical education, Dr. Johnson writes thus:

[1] "The Training of Men for the Profession of Chemistry," *Science*, **64**, 74–7 (1926).
[2] "Science for Humanity's Sake," *Ibid.*, **64**, 77–80 (1926).

Our institutions of higher learning deserve especial consideration, as they have been the most powerful stimulus to the general activity in science of the entire United States and have been the means of awakening the public mind to the importance of a study of chemical science, giving the same a rank in the general estimate never before attained. We recognize the fact today that the acquisition of a knowledge of chemistry and the part it plays in the promotion of human welfare is necessary for the proper rounding out of a cultural education. In fact, on every hand has the educated mind of America been directed toward all departments of scientific study. Chemistry is recognized today as a factor of major influence in our everyday life, an agent of power influencing and directing the growth and prosperity of our country.

The influence of the teacher on the progress of both science and education is by no means negligible. Again quoting Dr. Johnson:

The majority of the chemists who have attained prominence in their profession can generally point to one of their teachers as the original bearer of the torch which gave them light and inspiration leading to future success in life. There is no pleasure more gratifying to a teacher for the service that he renders than the experience of living to see some of his students attain success in their professional careers and to feel that he played an important part in their accomplishments. The remark is very often heard today that college professors, who used to make most of the discoveries in science, are now being hard run by the scientists in the laboratories of industrial organizations. While this statement is very probably true in some degree, I am not ready to admit that we have reached that stage where our professors must abdicate entirely in favor of their industrial comrades. The greatest accomplishment of all research is the discovery of the young genius who gives promise of developing into an original investigator. In this service we shall always need inspiring teachers and when such men are found in our colleges I have no fear that they will need to abdicate in favor of their industrial brethren.

Today, in this country, we have excellent facilities for advanced educational work in all the branches of chemistry. Dr. Johnson tells us that:

Today just as good opportunities are given in American universities for advanced research in all branches of chemistry as can be found in foreign laboratories. A certification of proficiency in chemistry received from an American university of recognized standing is just as valuable today as one received from a foreign university. In our advance we are gaining strength and contributing to the world's knowledge. We find scientists in both our academic and industrial institutions, and in the words of W. H. Perkin, "There is no chasm between pure and applied science, they do not even stand side by side but are linked together".....

Great investigators in chemistry, like great men in anything else, are born not made, but when they are born it is necessary that they be trained and the place for their training in chemistry is the university or technical school.

W. R. W.

RESEARCH

Recently there has come to our attention, from widely varying sources, an abundance of material on different phases of the general subject of

"Research." In an editorial in *Sierra Educational News*,[1] we find the following:

Research in education does not begin and end with the gathering of statistics. It is necessary in this scientific age to know why we follow a given course and the results from such a procedure. Studies and investigations must be set on foot and carried to logical conclusions. The findings from these researches must be interpreted in terms of public education. In projecting these researches the major objectives in education must always be kept in mind but personality and prejudice must never cloud the issue. Any investigation must stand on its merits and must seek to disclose the facts without regard to persons in power or policies in force. And no study or investigation should be carried forward unless from the body of data assembled, conclusions are deduced and implications made therefrom.

We quote further a comment on the "Functions of Research."[2]

Investigators are constantly making discoveries that the majority of the well-informed have known for a long time. It is an interesting observation that the public generally will applaud a statement of an established truism as though it were a recent discovery. This is especially true in the field of education. During the past year, in our own state (California), we have listened to specialists present the merits of home economics subjects, for example. These specialists have told of some of the methods employed and of the worthwhile achievements in this phase of education, while other outstanding educators have listened and accepted these pronouncements as "*new* and before untried." It should have been generally known that these same methods were used and like results achieved in forward-looking schools a quarter of a century ago.

The real significance of research lies in its many contributions to the development of a technic of coöperation says S. A. Curtis in a recent article.[3] Quoting him,

Research is ordinarily valued because it results in the discovery of truth. This is, of course, its primary function. However, as soon as we array the reasons why the discovery of truth is itself of value, considerations come to mind of such significance and far-reaching consequences that our estimate of the worth of research rises to new and much higher levels. My thesis is that the supreme value of research lies in the power of truth to harmonize conflict of human opinion and make coöperation possible.

And again he writes:

We have a proverb, "Two heads are better than one." But a measurement man is never satisfied with a mere statement of difference; he cannot be satisfied until he has measured the magnitude of the difference. In this case, however, the answer ranges from two to infinity. It is the miraculous power of coöperation to create something out of nothing. Two equally able individuals, meeting head-on, achieve nothing. Each stalls the other and their creative energy expends itself in hatred, the lust to kill and other undesirable emotional reactions. As soon as harmonization takes place, and the two coöperate in achievement, their energies are expended in profitable work,

[1] "Division of Research, C. T. A.," *Sierra Educ. News*, **22**, 371 (1926).

[2] *Ibid.*, **22**, 372 (1926).

[3] "The Contributions of Research to the Harmonization of Opinion," *Sch. and Soc.*, **23**, 707–10 (1926).

the fruits of which are love, joy and happiness. The real problem of human living is this—to play a contributing coöperative part in the great struggle for human betterment, the first step of which is the harmonization of the senseless conflicts in which we uselessly dissipate our divine powers of creative self-expression. And the master tool in such harmonization is coöperative, impersonal, objective, scientific research.

In the *News Edition* of *Industrial and Engineering Chemistry*[4] we find the following, quoted from *Oil-Power:*

The prodigal use of the supposed limitless resources of this country has been the foundation on which huge industries have been built. In recent years it has become apparent that these natural resources have a limit and that our national wealth and security depend in a measure upon their conservation. The realization of this fact is responsible for the birth of the art of industrial research.

Scientific research is as old as humanity. Its inception is the physical satisfaction of human curiosity. Industrial research is the application of scientific research to the arts and industries to the end that the living plane of mankind may be raised and that the world's natural resources, mankind's heritage, may be conserved.....

Those charged with the control of industries today are responsible that their industry, by research, shall add its mite to human progress and to conservation. If the result is individual success then the reward should be the sweeter for having raised others a step along the ladder.

Herbert Hoover in addressing the American Society of Mechanical Engineers[5] makes a plea for greater financial support of pure science research. Although we have developed our industrial research to a very great extent during recent years we have not kept pace in the development of research in pure science. And yet it is the industrial investigators who demand most ardently the support of pure science. Mr. Hoover says:

If we were to survey the Nation we should find that the technically trained men engaged in pure science research fall into two main groups; on the one hand, those supported in the great pure science research institutions, and on the other, those in our universities or engaged in individual investigation. The number supported by our pure science research institutions, such as the Carnegie, Rockefeller, Smithsonian, and others, probably does not exceed five hundred technically trained men. Those engaged in pure science research in our universities or upon their own resources probably do not exceed five thousand, and most of these devote only part of their time to this work. And there are some men in our industrial laboratories who are engaged in pure science work. It is an interesting contrast that the scientifically trained personnel in applied science investigation today probably exceeds thirty thousand.....

It is on the men in independent research and in our educational institutions that the great burden of scientific advancement must always rest, and from them that the inspiration of the younger generation of oncoming scientific workers is derived. What we need above all things is the better support of these men. They should not, by the necessities of living and the cost of equipment, be forced into our industrial laboratories. Those men who show an aptitude for research should be less engulfed in teaching.

[4] "Research," *Ind. Eng. Chem.* (*News Ed.*), **4**, No. 13 (1926).

[5] "The Vital Need for Greater Financial Support of Pure Science Research," *Reprint and Circular Series of the National Research Council*, No. **65**,

Often their productivity can be greatly aided by being released from teaching and administrative demands, and endowed in research positions. Much can also be done by providing them with instruments, skilled assistants, measurers, computers, and stenographers, and all the aid that the nature of their researches and the most economical use of their time may demand. To attempt to herd them into great laboratories even for pure research is often their least useful service. To alter their mode of life and thought would merely result in the exhaustion at the source of the vital essence of their success. Moreover, the very researches which they prosecute and the discoveries they achieve demand just such concentration of attention and originality of perception as their freedom tends to foster.

We quote in conclusion the final paragraph of an article by Edwin A. Lee.[6]

Most important of all, when all is said and done, is the necessity for imbuing those whom we have trained with the spirit of research. We may investigate and study and make reports without end if the end-point is only to turn out an individual well-trained for a given task but with no ability or urge to continue independent investigation. The significant evaluation we must make of our vocational teacher-training program, which we must make of all teacher-training programs, is whether or not those whom we train leave us with an irresistible urge to know the truth. Given that, our schools will advance, our profession will increase in power and dignity, the civilization we serve will grow in wisdom and joy. Lacking that, we shall worship the God of Things as They Are, for it is only from him who is on fire that another can light the torch.

W. R. W.

SUCCESS?

Quite frequently we hear the college graduate criticized on the score of deriving little or no monetary gain as the direct result of his four-year habitation at a recognized institution of learning. It has been suggested that the individual has been successful in the light of what he had sought in education, which was a knowledge not of how to make money but of how to make something of himself. "Education," writes Raphael Demos,[1] "should be the process of forming a personality which may function in the world of work and yet be out of it, of cultivating those intellectual and spiritual interests by reference to which only has work or life any importance." He further says:

The function of education is not to stuff the mind with facts, but to teach one how to handle them; not to make one into an expert, but to show one how to choose an expert; not to give one a ready-made solution for specific problems, but to make one so resourceful that one may be ready for any contingency. Not memory but intelligence, not knowledge but power—this is the objective in college. Clearly, the means by which education seeks to achieve its end are roundabout; while taking this or that

[6] "Research Problems in Training Vocational Teachers," *Sch., and Soc.*, **24**, 31–7 (1926).

[1] "Education and Business," *Yale Rev.*, **15**, 725–34 (1926).

course, one is not just trying to learn all about a given field; one is rather acquiring a method of thinking, a conception of cause and effect, and a feeling of law and the systematic character of things; one is cultivating an intellectual imagination that sees beyond the immediate. But mere training of the mind is cleverness, and this is not enough. The student must develop an appreciation of ideals and learn to distinguish the genuine from the counterfeit in the fields of ideas and of art, among persons and causes. Far more important than knowledge of the technic of life is wisdom, which is knowledge of the ends of life. How is this quality of wisdom to be imparted to the student? Certainly not by word of mouth or by any intellectual instruction. Contagion is the only way, that is to say, the influence of example in history, biography, art, in personal contacts with great minds and great men. We must admit that our colleges have not attached to this phase of education the importance which it merits.

Success in business is not comparable with success in education, for what makes for efficiency in business makes for inefficiency in education. We cannot ask for immediate results in education. Mr. Demos tells us that:

You cannot draw any sound analogy between the production of knowledge and the production of goods; education deals with persons while industry deals with things. As soon as you standardize the educational procedure, you lose what is so absolutely essential—individuality in the product. Knowledge is not a piece of merchandise to be transmitted across the counter to the student consumer; it is an achievement for oneself, as personal as the color of the eyes. The success of modern industry comes from its state of perfect organization, and the public is apt to draw the conclusion that learning, too, consists of a systematic arrangement of information. So we get the type of mind in which thought has been nicely arranged into a pattern, with each idea referred to its proper place. For such a mind to think is to classify, to fit into an outline. Now, this is neat, but it is not thought; it is rather a mechanical moving of counters into their squares. Instead of dwelling on the substance of the question, one settles it by simply relating it to predetermined categories. Thought becomes formal—a shuffling of symbols. In reality, thought is a dynamic impulse which may never be tamed into submission to formulas; it is a movement, a transition, and therefore essentially unfinished and overflowing all outlines. To organize thought too perfectly is to kill this impulse and this movement.....

We should guard against applying the test of success to education too narrowly. It may happen, for example, that at a given period intellectual or artistic production receives no appreciation from the world; at such a period it may well be that academic instruction is a definite hindrance to success. Does it follow that education under those circumstances is a failure? No, because such a world would be not worth succeeding in; the state of affairs would be an indictment of life itself, not of the school. The reader will say that this is too utopian, and not practical. In reply, I would point out that the view of education as a preparation for life is only half true. Education not only prepares for life, it makes life; it is life. The world is not something fixed and immutable, to take or to leave. Education is always molding the world by molding those who live in it; it is the workshop of life, in which humanity thinks and works out new standards and ideals for itself. If life happens to be below the requisite intellectual and cultural level, then, rather than compromise with the world and seek to turn out potential businesss successes, education should endeavor to lift the level of life. Education must be adequate to life, and life must be adequate to education.

Has our college work been worthwhile? According to Mr. Demos:

College education may not provide actual knowledge, but it provides a map of knowledge to guide the mind in its maturer studies. College education is a useful preliminary for the maturer education of life; without it we would find it very difficult to direct and organize our intellectual life in the years of middle age and after. But it is also evident that, unless we do continue it in our years of maturity, college education remains of very little value. Here life must help; the world of affairs must be so organized as to permit the mind to continue its education. Business must never be so engrossing that one has no time to reread the classics or pursue one's intellectual interests. But it is not merely a matter of having the time for such pursuits, outside of one's work; what is needful is that work itself should be mentally cultivating, that life should include thought and artistic interests, so that the individual may participate in these activities naturally as part of the process of living, without having to say to himself: now I must cultivate my mind. Clearly, life has its part to play in the task of education, and to be adequate to this part, it must sustain itself at a certain spiritual level.

Thought must not remain apart from action. We again quote Mr. Demos:

Work is nothing but systematic productive activity, in which the personality finds an opportunity for concrete self-expression.....The energies of civilization should be marshalled to the task of humanizing work, that is, of connecting work with the springs of personality, and making it more imaginative. When thought and action are divorced, we get the pedant on the one hand and the intellectually tired business man on the other; to join the two is to give vitality to thought and vision to work. Hence the importance of incorporating business schools into the university. If business is not a profession here is an opportunity for our educational institutions to help it become one, by welcoming it into the fellowship of the arts and sciences and exposing it to the winds of academic tradition.

Our universities are being invited to assist this process and to help business become a more scientific and a more humane enterprise. But it would be almost criminal were they to accept the current conception of business as a means of private profit and to engage in teaching their students how to make money as quickly as possible. What the universities should do is to present the conception of business as an instrument of social service, and by thus presenting it to help translate the conception into a reality.

W. R. W.

World's Record Chrome Ore Deposit Found in Montana. A chrome ore deposit, said to be the largest known in the world, has been discovered near Columbus, Mont., on the edge of Yellowstone National Park. Prof. James F. Kemp of Columbia University, New York, after a close scrutiny in company with representatives of the U. S. Geological Survey, announced that the find is of importance to the metal industry of the world not alone because of the well-known rust-resisting properties of chromium-steel alloys, but also because chromium is rapidly supplanting nickel in the electroplating industry, its only disadvantage having heretofore been its higher cost.

Practically all of the chrome ore used in this country previously has been mined in Rhodesia, South Africa, selling in this country at about 40 dollars per ton. The Montana ore, after being refined at smelters and chemical plants now being erected, can be sold at about 20 dollars per ton.—*Science Service*

ABSTRACTS

The Value of Intelligence Tests. HERBERT SIDNEY LANGFELD. *Forum*, **76**, 276–9 (1926).—Of two boys of the same age and in the same class in school one studies all his free time, the other hardly ever looks at his books. Yet they both get the same grade in a final examination. What does this grade really mean? Such problems as this one influenced Alfred Binet to devise a scale for measuring native ability. Binet was primarily interested in determining the levels of intelligence of the individual child. For this purpose a small group of questions for each age up to twelve years was arranged. These problems were selected after he had determined that they could be answered by the majority of children of the age for which they were intended. If a child answers the questions up to and through the twelve-year group, he is given a mental age of twelve. This figure is then divided by the chronological age and the result is called the intelligent quotient. Various revisions of these tests have been made and they have been used extensively throughout this country. It has been found that environmental conditions, language differences, and the like influence the results of these tests and much research is now in progress on the problem. It is admitted that in the present stage of development of the tests, they are of greatest value when used for comparative purposes on children who are of the same environment and who have had approximately the same advantages.

At the present time there is considerable interest in the use of intelligence tests in connection with college entrance examinations. The old essay examination is not entirely satisfactory and needs supplementation. The intelligence tests that are used in the colleges are modeled after the army tests. They consist of a series of questions and problems ranging from simple tests of ability to follow instructions accurately, to more exacting tasks which demand a higher degree of logical thinking. A number of colleges and universities are now using intelligence tests to supplement other forms of examinations.

A description of the manner in which intelligence tests are being used at Princeton University under the direction of Professor Carl Brigham is given. It is also stated that intelligence tests have been adopted by the College Entrance Examination Board and a committee of psychologists with Professor Brigham as chairman has been appointed to administer them. W. R. W.

"Seeing" with X-Rays. F. K. RICHTMYER. *Sci. Monthly*, **22**, 550–4 (1926).—A popular lecture on the discovery and general uses of X-rays including their use in connection with the study of atomic structure. A very good word picture of the atom is given. G. W. S.

What Is an Element? ROGER C. WELLS. *Sci. Monthly*, **22**, 554–6 (1926).—The author gives a popular discussion of the chemical elements showing their relation to each other and the meaning of the atomic numbers and isotopes. G. W. S.

The Present Status of the Theory of Relativity. PAUL R. HEYL. *Sci. Monthly*, **23**, 65–70 (1926).—The positive result obtained by D. C. Miller in the spring of 1925 when he repeated the famous Michelson-Morley experiment on the top of Mt. Wilson for the detection of the supposed motion of the earth relative to the ether gave a new impetus to the theory of relativity. The result was positive. It appears also from theoretical considerations that a condenser suspended from a fine filament with its plates inclined to the direction of the ether-drift should, upon being charged, experience a torque. This experiment, first performed by Trouton and Noble, was repeated by Professor Tomaschek, of Heidelberg on the Jungfrau, at an altitude twice that of Mt. Wilson, with a negative result.

The three experimental tests of relativity suggested originally by Einstein were the irregularity in the motion of planet Mercury, a deflection of light rays passing near the sun, and a shift of the Fraunhofer lines in the solar spectrum. Of these the first was the earliest to establish itself. It was a fact that relativity explained. The other two were predictions not known to exist. The Lick Observatory expedition to observe the eclipse of 1922 confirmed the second. The third test has been more difficult to confirm because of its small magnitude. Contradictory results were announced by several observers, and much uncertainty existed until Adams, of the Mt. Wilson Observatory, succeeded in photographing the spectrum of the faint companion of Sirius. The very great density of this star gave a correspondingly great value to the Einstein shift. The result was positive.

Other experiments to test the fundamental postulate of Einstein's gravitational theory are described, the results of which were not conclusive. The evidence, therefore, in the case of the special theory is conflicting. The experiments of Tomaschek,

of Raleigh and Brace and the original Michelson-Morley experiment all point to the non-existance of ether-drift, while Miller's later result points to an ether-drift. With the general theory the evidence is entirely concordant with the exception of one result which is ambiguous. G. W. S.

A Study of the Vocabulary of Scientific Articles Appearing in Daily Newspapers. FRANCIS D. CURTIS. *Sch. and Soc.*, **23**, 821–4 (1926).—The writer concluded from a previous study of the subject that the range of scientific vocabulary found in the public press emphasizes the need for extensive training in science as a foundation for the intelligent reading of the newspapers. The present study represents an attempt to secure data relative to the vocabulary used in scientific articles appearing in the daily press: (1) What percentage of the total vocabulary are common English words, (2) what percentage of the total vocabulary are scientific terms; and (3) what percentage of the uncommon words are scientific terms. The materials used in this investigation were six hundred thirty articles of miscellaneous scientific content published in two weeks' consecutive issues of six American newspapers representing widely different parts of the country and types of cities. The selection of articles included all having scientific content which appeared in the issues of the six newspapers studied except the weather forecasts and the death notices. No advertisements were included.

The results were as follows: (1) There is no apparent relation between size of circulation or national importance of these six newspapers and the percentage of scientific terms which appear in the miscellaneous scientific articles of the issues studied. (2) The percentage of uncommon words found in the articles is small. (3) The respective percentages of uncommon words appearing in the articles are approximately equal. (4) There is a considerable degree of uniformity in the respective percentages of scientific terms found in the uncommon words composing these articles. (5) Slightly more than two-thirds of the scientific terms appearing in the articles appear also in the "The Teacher's Word Book" by Thorndike.

Dr. Curtis says: "If pupils are to receive in the schools adequate training for an intelligent reading of the science appearing in the public press, further studies should be made aiming to ascertain the scientific terms which appear most frequently in the daily press. The pupils must then be given specific training and drill, affording them a familiarity with, and an understanding of, the scientific connotations of these more common scientific words, both those which are and those which are not included in lists of common English words.

"It seems probable that such a list of scientific words objectively selected as a basis for training in reading newspaper science will be found to contain much of the special scientific vocabulary needed for an understanding of magazine science."

W. R. W.

The Growth of Crystals. C. H. DESCH. *Nature*, **117**, 694–5 (1926).—Substance of two lectures delivered at the Royal Institute in March, 1926. H. K. M.

Rustless Steel and Flexible Glass 5000 Years Ago? J. H. GARDINER. *Nature*, **117**, 791 (1926).—It is stated in "Glass in the Old World" by M. A. Wallace-Dunlop on authority of Ben-Abd-er-Rahman, that in the year A.D. 829 El-Mamoun was the first who succeeded in penetrating the tomb of Cheops and entered the west pyramid (second?). And that there were found besides the treasures and precious stones, "instruments of iron and vessels of earth and with arms which rust not, and with glass that might be bended and not broken." These pyramids are known with tolerable certainty to have been built between 3969 and 3845 B.C. H. K. M.

The Element of Atomic Number 61; Illinium. J. A. HARRIS, L. F. YNTEMA, AND B. S. HOPKINS. *Nature*, **117**, 792–3 (1926).—A brief review of the history and method of discovery. H. K. M.

The Periodic System, Chemical Bonds, and Crystal Structure. A SOMMERFELD. *Nature*, **117**, 793–5 (1926).—From a series of University of London lectures on Atomistic Physics delivered at the Royal College of Science during March, 1926. H. K. M.

The Use of Intelligence Tests by Universities. HERBERT A. TOOPS. *Sch. and Soc.*, **24**, 87–8 (1926).—This article gives an account of the attempt to determine what working principles have been developed by universities in regard to tests. A questionnaire was sent to 110 colleges and universities and replies were received from all 110. The conclusions derived from the replies of the 66 colleges using the tests in 1923–24 are: (1) The growth of the use of tests has been steady and consistent. (2) Smaller colleges with lack of testing personnel do not use tests to the same extent as the medium-sized colleges. (3) The Thorndike test was found to be displacing the Army Alpha to a great extent. (4) There is a direct relation between length of test and size of validity coefficient reported. (5) The median validity coefficient reported

by forty-three colleges is 0.46 while twenty-three colleges do not know the validity of the test used. (6) No college uses tests as a sole basis for entrance. (7) Sectioning of students on the basis of capacity has made only a slight headway. (8) Seventy-three per cent of the colleges using tests give out to students the results of their tests. (9) Every second college has a demand for at least two sets of the test records for the use of different administrative officers. (10) Eighteen colleges have computed the reliability coefficient of the tests used by them. Their average reliability coefficient is 0.87 which is rather good. (11) The results both as to validity and reliability achieved by the colleges reporting point out the desirability of general adoption of tests of at least two hours in length. (12) College marks have a higher reliability than might be expected. W. R. W.

Educational Publicity in the Teachers' College. JOHN H. BUTLER. *Sch. and Soc.*, **24**, 50–2 (1926).—The teachers' college no longer concerns itself only with the training of teachers. It uses its training school as a laboratory in which it tries to evolve newer and better methods of teaching, better curricula, and many other things that make for the advancement of education. There is a great gap between educational theory and educational practice. A few professors of education realize the situation and warn their students of what awaits them when they go out to take up their work in the schools. The lack of knowledge of school matters on the part of the public is responsible for the fact that school people do not get the proper backing so that they can teach as they should. The public must be educated to the value of the educational theories worked out in the teachers' college. The author says: "With an intelligent public behind him, a public that knows the value of a junior high school before it is asked to vote upon it, a public that understands the theory of intelligence testing before—as a result of such tests—some of its children are put in special classes for the inferior, with such a public behind him a city superintendent can do something. But only one in a thousand communities are so educated; only one in a thousand superintendents is either so wise or so capable as to educate his public."

The teachers colleges must educate the public as well as the teachers and must carry the public along with the progress of education so that when the college sends out its teachers they will meet with a hearty welcome and coöperation instead of opposition. The newspapers are anxious to have such information if it is written up so that the laymen can and will read it. Magazines want articles properly written.
W. R. W.

Iron in Antiquity. J. N. FRIEND. *Nature*, **117**, 862–3 (1926).—Substance of a lecture delivered to the Royal Institute on June 3rd. Of special interest to teachers of elementary chemistry. H. K. M.

The Isotopes of Sulfur. F. W. ASTON. *Nature*, **117**, 893–4 (1926).—Aston has been able to raise the resolving power of his new instrument to about 5 times that of the old one, sufficient to show the lines of O and CH_4 clearly separated by more than $^1/_2$ mm. There is now no reasonable doubt in the case of sulfur: it is a triple element like the two even ones, magnesium and silicon, which precede it in the periodic table. The lightest mass number is far the most abundant in all three cases. S^{34} appears to be about three times as abundant as S^{33}: the two together probably amount to three per cent of the whole. H. K. M.

The Origin of Petroleum. H. B. MILNER. *Nature*, **117**, 897–8 (1926).—Milner points out that with the science of petroleum the problem of its genesis remains paramount. It was not only appropriate but essential that to avoid further confusion some one should see around rather than into the problem of mineral oil origin, that ground should be cleared by correlation of definite data of constructive theories, thus propounding a unified hypothesis from which future research could trend with some hope of positive results. It is from this viewpoint that Mr. Ernest Clark has surveyed his subject. At the outset he tacitly discards all theories of inorganic origin of petroleum, so that we are saved the boredom of recapitulation of text-book paragraphs. He takes his stand on organic theories, and in this the majority is undoubtedly with him. H. K. M.

The Pupil and the Student. NEVIN M. FENNEMAN. *Sch. and Soc.*, **23**, 665–9 (1926).—The term pupil designates one who is learning lessons generally by way of regular hours of class work, assigned preparation, and frequent tests. The independent student is something quite different from the pupil. The problem of getting out of the pupil stage and into the student stage is one of the most difficult problems of the American universities. It is tacitly acknowledged by most men who think at all that the transition is not being properly made. The merging of pupils and students in the same college tends to obscure and stunt the student and to delay intellectual maturity by an undue prolongation of tutelage.

Four conceivable ways of solving the difficulty are listed by the author. The first solution is to leave the organization as it stands and make greater efforts to segregate students from pupils. A second plan would be to devote the whole of the four-year course to pupilage and leave the break to the graduate school. A third solution would be to plunge freshmen at once into independent study. A fourth solution of the problem of transition is to split the college in the middle. This would necessitate the separation of the junior college and the university. The advantages and disadvantages of the above solutions are discussed. W. R. W.

Why Not Give Students a Contact with Research Work? A. W. FORBES. *Sch. and Soc.*, **24**, 22–3 (1926).—It is frequently stated that professors should engage in research work although the object of the research is not so clearly stated. If it is the advancement of scientific knowledge that is sought, the professor is only encumbered by contact with immature students. If the student is supposed to come in contact with the professor in such a way that the research of the professor will serve as an inspiration to him, this contact is sadly lacking. The student with the intellectual initiative necessary for successful research has sufficient interests of his own so that he does not try to break through the professor's protective shell. The writer considers that he came in contact with research more actively in the factory than during any time of the six years he spent in college. It was easier to talk things over with the responsible men directing the factory research than it was to talk with a professor. Quoting the author: "Coöperative education is my solution, but not the kind of coöperative education which is now being pushed by various schools. So far as I know, all coöperative courses are planned with the idea that the factory is for practical experience only, and that all the higher educational functions are to be found in the school alone. It is only possible to make the factory of more value in education by deliberately planning the program with the idea of so using it." W. R. W.

Sulfuric Acid—"The Warhorse of Industry." ANON. *Drug and Chem. Markets*, 19, 15–9, 62 (1926).—Sulfur is the most important chemical raw material in modern industry. Is the source of 75 per cent of our H_2SO_4; is our most valuable agricultural insecticide; is necessary in rubber vulcanization, etc. The status of the sulfuric acid industry has changed greatly since the war; its production in the U. S. has almost doubled, as is shown in the accompanying table:

	Pre-War	Present
Fertilizers	2,250,000 tons	2,000,000 tons
Petroleum	300,000	1,500,000
Chemicals	350,000	1,000,000
Steel and Iron	200,000	650,000
Other metals, batteries, etc.	75,000	500,000
Explosives	150,000	200,000
All other industries	225,000	650,000
Total	3,550,000 tons	6,500,000 tons

Prior to the war, about one-half of the H_2SO_4 in the U. S. was produced from pyrites, 30–40 per cent as a by-product in smelting Zn, Pb, and Cu ores and the balance from brimstone. Today 75 per cent is made directly from brimstone and 25 per cent, fairly evenly divided, comes from roasting pyrites and from smelter operations. Prior to the war the U. S. imported an average of 1,000,000 tons of pyrites and produced domestically 350,000 tons. In 1925 we imported but 276,385 tons and produced but 170,081 tons.

The war not only created a tremendous demand for H_2SO_4, but it also shut off the flow of pyrites from Spain. The price of the acid advanced 500 per cent above normal. The war ended with a large amount of acid being made directly from brimstone. To prevent manufacturers from returning to pyrites, the price of sulfur was dropped from $22 at the mines to $14 (price in 1922).

Following a brief history of Sicilian sulfur, the author discusses the situation in the U. S. today. In 1903 the Union Sulfur Co. first pumped crude sulfur out of deposits in Louisiana by the Frasch process. It enjoyed a virtual monopoly until 1914, when the Freeport Sulfur Company came into production. In 1919 the Texas Gulf Sulfur Company began operations. Two years ago operations at the Louisiana mines of the Union Sulfur Co. were suspended—not because the sulfur is exhausted but because cave-ins and fissures have made the business unprofitable. Today 80 per cent of the world's sulfur comes from the 3 mines being operated by the Freeport

and Texas Gulf Companies. The Union Sulfur Company is shipping from accumulated stocks while actively prospecting for new deposits. Government experts estimate that the two former companies have "in sight" about 20 years' supply, but there are known to be vast deposits in Louisiana, Nevada, and Utah, in addition to the practically limitless supplies of pyrites. Consequently, the price of sulfuric acid will probably remain fairly stable. R. A. B.

Kinds of Examinations. DANIEL HANNON. *Chicago Sch. J.*, **8**, 337–9 (1926).—The various kinds of examinations now in use are enumerated and discussed. The best known form of examination is what is called the essay type. In this form, questions are prepared by the teacher on the subject-matter studied for a month or term and the pupils write out their answers to the questions in accordance with the knowledge they have. Another form is the true-false or right-wrong test in which a number of statements prepared by the teacher are submitted for the pupils to mark. The multiple choice type is also used in which several statements about a fact are given, only one of which is correct. The test of the pupil's knowledge is in his selection of the correct statement. A test similar to the multiple-choice type is known as the best answer choice form. The test of the pupil here is in selecting the best statement in the list. The completion test is one in which the pupils fill in omitted words in a list of sentences. Still another form of the new type examination is that in which the pupil is asked to indicate which facts in two lists belong together. The two lists are arranged in parallel vertical columns convenient for the pupil to study. The test of the pupil's knowledge in this form is his success in bringing each event into relationship with the year in which it took place. This test can well be adapted to other subjects than historical events.

One fact to be noticed about these forms of examinations is the very definite answers or responses that pupils are to make to the statements or questions. Except in the completion form the writing required of pupils is limited to writing a single word or letter or underscoring. This feature is in marked contrast to the usual essay-type examination in which pupils are required to do considerable writing. The scoring of the two types of examinations stands out in contrast also. The objective nature of the results of the new-type examinations is regarded as the most important advantage in their use. A list of references is given which the writer considers of value to the class-room teacher unfamiliar with the more technical phases of the science of education. W. R. W.

Advantages and Defects of Examinations. DANIEL HANNON. *Chicago Sch. J.*, **8**, 380–2 (1926).—Two types of examinations are discussed as to their advantages and defects, namely, the essay type and the new or objective type.

Advantages of the essay type are pointed out as being: (1) Pupils can organize their learning and use language in a free fashion. (2) It provides an excellent means of review for pupils. (3) Part or all of the questions in the essay examination can be so prepared and worded that learned material will be reorganized in such ways that new learning takes place. (4) It is a valid test if carefully prepared and results carefully scored according to standards laid down in advance of the scoring. (5) It is easy to prepare and administer. The disadvantages are: (1) It is not objective in the sense that teachers in grading the results are guided very largely by personal ideas. (2) It tests too many abilities of examinees at one time. (3) The sampling of pupils' knowledge is too limited. (4) The interpretation of questions in preparing answers is often difficult because of the general nature of such questions. (5) Teachers must devote an enormous amount of time to reading and scoring the results of the essay examinations.

The advantages of the objective type of examinations are: (1) It is almost completely objective. (2) It is extensive in the sampling of pupils' powers. (3) It is likely to be of greater validity than the essay type. (4) Pupils in preparing answers are called upon to respond in a fashion not calling for the exercise of several accessory abilities. (5) It may be composed of several different types of tests all to be given during the same school period. The disadvantages are: (1) The guessing element is too prominent in designating the answers. (2) The testing is exclusively of factual knowledge. (3) Pupils do not "do something" with their knowledge. (4) The objective types are difficult to prepare.

Each advantage or defect is discussed and conclusions drawn. W. R. W.

The Determination of Traces of Mercury. Quantitative Determination of Mercury in Presence of Organic Matter. H. S. BOOTH, NORA E. SCHRIEBER, AND K. G. ZWICK. *J. A. C. S.*, **48**, 1815–24 (1926).—The classical Stas-Otto process for decomposing organic matter by means of potassium chlorate and hydrochloric acid yields mercury as the volatile halide. A method is given whereby potassium per-

manganate and sulfuric acid may be used and no mercury is lost by volatilization. The important observation is then made that hydrogen sulfide precipitates small amounts of mercury partly as colloidal sulfide and partly as other colloidal compounds, and that these are completely adsorbed by co-precipitation with a little manganous hydroxide. The precipitate is dried, oxidized by lead chromate in a small glass tube whose construction and packing are shown in a diagram, and the mercury collected in a small capillary. Its mass is calculated from micrometric measurements of the length and bore of the tube. The authors conclude that no method which fails to take account of the adsorption of colloidal mercury compounds by co-precipitates can be accurate. A. P. B.

Electron Displacement in Carbon Compounds. Derivatives of Benzene. HOWARD J. LUCAS. *J. A. C. S.*, **48**, 1827–38 (1926).—The idea is set forth, in four postulates, that inner electrons act as screens between the outer electrons and the nucleus. This idea is then extended to hold for shared electrons in the valence shells of atoms. The author also postulates, with Noyes, Knorr, and others, that shared electrons move in orbits which encircle both nuclei. The above postulates are used to explain, in a very satisfactory manner, the fact that electro-negative groups substitute ortho and para in the benzene ring, whereas electro-positive groups substitute meta. According to Pauling's structure for benzene, every carbon nucleus in the ring is held in common by the electron orbits of both the ortho and para carbons, but not the meta. Seven rules for substitution are listed, which agree in the main with observed facts. The author concludes that the ionization constants of the PARA-substituted benzoic acids serve as a measure of the relative electron attraction of radicals, and lists values for fifteen substituent groups in confirmation of this view. A. P. B.

Contact Catalysis and the Mechanism of Chemical Reactions. WILLIAM FOSTER. *Discovery*, **7**, 233–5 (1926).—An article giving an historical account of the development of the theories of catalysis. Catalysts are adding greatly to the wealth of nations. This is illustrated in the Haber process for the production of ammonia and the use of nickel in the hydrogenation of animal and vegetable oils or the production of solid fats. Three hundred million pounds of oil are being hydrogenated annually by the catalytic process in the United States, producing fat equal to that obtained from 7,000,000 hogs. Hydrogenation adds over £4,000,000 annually to the value of American cotton-seed oil. Germany, in 1925, exported Haber products valued at more than £4,000,000. Comparatively little is known about the real nature of contact catalysis and the mechanism of chemical reactions. Various hypotheses have been advanced but most of them have been unsatisfactory. The author outlines the theory of H. S. Taylor and his co-workers at Princeton University.

In certain reactions involving gases made up of diatomic molecules, there is evidence that in the presence of catalytic metals some of the gas is present in the atomic condition on the surface of the catalysts. For instance, there is proof that atomic hydrogen is present on nickel and on copper and that both diatomic hydrogen and nitrogen molecules yield the corresponding element in the atomic state in the presence of iron. The abnormal action of monoatomic hydrogen is of importance in the problem of hydrogenation catalysis. Taylor and Marshall have succeeded in forming hydrogen peroxide by the interaction of hydrogen and oxygen in the presence of excited mercury vapor and formaldehyde by the interaction of carbon monoxide and hydrogen in the presence of excited mercury atoms. The quantum yield in both cases is 30 or 40 molecules of aldehyde for every quantum of light absorbed by the mercury vapor. W. R. W.

Education—Man vs. Mass. ARTHUR ELMORE BOSTWICK. *Library J.*, **51**, 605–7 (1926).—The old question of individualism versus collectivism is again discussed. While every child is different from every other child and, therefore, needs separate methods of training and content of instruction, he must live his life in contact with thousands of others and, therefore, education in mass would seem advisable for every one. The most plausible method of training, according to the author, is to use collective training thoughout but to encourage individual thought and initiative, laying emphasis on the development of individual character but modifying and adjusting that character by contact with others. The author cites the public library as being better fitted to combine the personal and mass methods of education and to vary the exact proportions of both in accordance with the requirements of the moment than any formal system. He says: "Nowadays we think more of specialization than of balance. If a man has a bent for mathematics, we push him as far as we can in that direction, or do not bother about his 'balance.' Perhaps we err just as seriously here as our fathers did in the other direction. Mr. H. L. Mencken has recently condemned

modern education as altogether useless, because, he says, it does not recognize individuality. Yet it is possible to accord it undue recognition, no doubt. We may overspecialize, but even our specialist is likely to be standardized. It proceeds along recognized paths. What we need is to encourage variation—to applaud deviation. To repeat what I have frequently said, no one ever got to a new place by following an old path. Of course, there are thousands of new paths that never lead anywhere, either. A sense of the probable futility of certain kinds of aberrancy is a good quality to have."

W. R. W.

Character-Education and Scientific Method. M. E. HAGGERTY. *J. Educ. Res.*, **13**, 233–48 (1926).—Scientific psychology may be applied to the solving of character problems which challenge all our educational endeavors to create a more satisfying human society. Many who go through our schools fail to meet character tests of life with adequate strength of personality, being deficient in honesty, courage, self-control, patriotism, and personal integrity. From figures cited for crime and mental disease it is apparent that American life yearly exacts a toll in broken character exceeding a hundred thousand individuals. In the borderland between the area of normal, happy adjustment of life and the territory of complete disaster dwell many times a hundred thousand individuals who fight incessantly for life against powers which, if not unseen, are little understood.

Scientific study shows that probably a large portion of human failure is preventable, a realization of which fact lays a heavy challenge upon education, since the individuals who compose this year's hundred thousand were but a little while ago the pupils in our schools.

The scientific method applied to this problem implies: (1) careful observation of human behavior under controlled conditions, (2) experimental analysis, (3) recording behavior, (4) generalization and prediction, (5) determination of methods of controlling situations so that desirable forms of behavior may be produced.

A million dollars a year devoted for fifty years to research in matters of intellect and personality would yield a wealth incalculably greater than is likely to come from one of the $50,000,000 battle-ships which we build so facilely and destroy so casually that the comparison seems child-like. It is hoped that society will somehow find the way to devote a larger portion of its resources to these important matters.

R. M. P.

Attempts to Fractionate Mixed Isotopes of Lead and the Atomic Weight of This Metal. T. W. RICHARDS, H. S. KING, AND L. P. HALL. *J. A. C. S.*, **48**, 1530–43 (1926).—Of the methods theoretically available for the separation of isotopes, only irreversible evaporation and chemical reactions seem at all promising in the bases for an elaborate and painstaking attempt to effect a separation. The Grignard reaction was used as most suitable for the chemical method. The procedure is described in some detail and several pages of data are included. No separation was attained by either method. The average of 18 determinations gives 207–217 as the atomic weight of lead, which checks well with the accepted value.

A. P. B.

Observations on the Rare Earths. XXIII. Element Number 61. Part One. Concentration and Isolation in Impure State. J. A. HARRIS WITH B. S. HOPKINS. *J. A. C. S.*, **48**, 1585–94 (1926).—A brief historical survey of the various attempts which have been made to isolate Element Number 61 is first given. The present work is the outcome of an agreement between the U. S. Bureau of Standards and the University of Illinois to investigate the arc spectra of many of the rarer elements, much of which has previously been published. It was noted that the wave-length tables contain about 1500 lines each for neodymium and samarium and about 130 lines common to both, and it was suspected that these lines might be due to Number 61. Accordingly fractionation of crude cerium group material was used as a starting point, as the double magnesium nitrate, but all fractions contained so little of Number 61 as to make its detection by X-ray analysis extremely difficult. The absorption bands of Number 61 are effectually masked by the broad bands of neodymium and samarium. Fractionation as the bromates reversed the order of solubilities, placing gadolinium between Number 61 and samarium and terbium between Number 61 and neodymium. Under these conditions absorption bands probably due to Number 61 become plainly visible.

A. P. B.

Observations on the Rare Earths. XXIII. Element Number 61. Part Two. X-Ray Analysis. J. A. HARRIS WITH L. F. YNTEMA AND B. S. HOPKINS. *J. A. C. S.*, **48**, 1594–8 (1926).—The authors formally base their claim to the discovery of a new element on three different lines of evidence. 1. The presence of lines in the arc spectrum of materials prepared in the laboratory common to both samarium and neodymium

and stronger in intermediate fractions. These consist of 130 lines in the red and infra-red and 5 lines towards the violet. 2. The presence in their intermediate fractions of absorption bands which become stronger as those of neodymium and samarium become weaker. The bands at 5816 Å. and 5123 Å. are especially prominent and their position confirms the belief that there is a systematic drift in the absorption bands of the rare earth group. 3. The presence of lines in the X-ray emission spectrum corresponding closely to the theoretical positions for the $L\alpha_1$ and $L\beta_1$ lines of Element Number 61. The mean value obtained for $L\alpha_1$ agrees within 0.0004 Å. of the value calculated from Siegbahn's precision values. The single reading obtained for $L\beta_1$ varies by 0.0040 Å. from the calculated value. A. P. B.

Observations on the Rare Eearths. XXIV. A Theory of Color. L. F. YNTEMA. *J. A. C. S.*, **48**, 1598–600 (1926).—Rare earth ions are characterized in most cases by extremely sharp absorption bands in the visible spectrum and in the small portion of the ultra-violet which has been explored. The striking similarity in chemical properties exhibited by members of the group is due to similarity of arrangement of outer or valence electrons. Differences in physical properties, then, such as color of compounds, must be due to differences in the arrangement in inner shells or levels. A careful study of the absorption bands indicates that the characteristic lines for each element have their origin in the fourth level. Lewis' observation that a great majority of the compounds of elements of variable kernel, which appear in the transition series of the long periods of Mendelejeff's table are colored, is discussed and applied. The author also points out that a fairly uniform curve may be drawn through certain absorption bands of seven of the rare earths, and discusses its possible significance. A. P. B.

Vitality in College Courses for Teachers. J. L. MURSELL. *Educ. Rev.*, **72**, 33–6 (1926).—A discussion of pedagogical training, the need of live teachers, the failure of their college courses to develop their abilities, and constructive suggestions for improving the output of collegiate courses in education. Although not dealing specifically with chemistry it would be well for many of our chemistry instructors to read this article. H. K. M.

The Transmutation of Elements. A. SMITS. *Nature*, **117**, 620 (1926).—Of the two possibilities of transmutation by absorption of electrons or by disruption of the atomic nucleus Smits considers the latter more probable in the cases of the transmutation of mercury and lead. This is a preliminary paper announcing that he is studying the quartz-lead lamp and examining spectroscopically whether the process is accompanied by the formation of helium or hydrogen and determining the atomic weight of the heavier products. H. K. M.

Potassium and the Heat of the Earth. A. HOLMES AND R. W. LARSON. *Nature*, **117**, 620–1 (1926).—It is pointed out that potassium as an emitter of radio-thermal energy is in the aggregate of the same order of importance as uranium or thorium. Illustrations of the geological significance are given. H. K. M.

X-Ray Identification of the Higher Fatty Acids. G. T. MORGAN AND E. HOLMES. *Nature*, **117**, 624 (1926).—Ultimate chemical analysis of higher fatty acids is inconclusive because of the very slight percentage differences in the elementary composition of these closely related analogous substances, but X-ray examination gives data which are more decisive. The authors have isolated from peanut oil an acid melting at 77° shown by X-ray examination to be a C_{26} acid almost certainly possessing an unbranched carbon chain. It is hoped by this method to clear up the controversy over the chemical constitutions of higher fatty acids from arachis oil. H. K. M.

Chemical and Physical Action at Surfaces. E. K. RIDEAL. *Nature*, **117**, 626–8 (1926).—A general review of the field based upon two lectures given at the Royal Institute in February. H. K. M.

The Present Position of the Transmutation Controversy. EDITORIAL. *Nature*, **117**, 758–60 (1926).—The experiments of Miethe and Stammereich, Duehm and Lotz, Nagaoka, and others are reviewed. The criticisms of the methods and the possibilities of gold distilling with mercury are discussed as well as Aston's weighty arguments against the probability of the alleged mercury-gold transmutation. Professor Haber has now communicated the results of the long investigation which show that the gold in all probability did not preëxist in the mercury but was derived from auriferous metal constituting the electrode or other metallic parts of the apparatus employed. He analyzed electrolytic copper wire, nickel wire, steel screws, and Swedish iron and found them all to be auriferous. Only thin tungsten wire contained no trace of gold. The silver obtained in transmutation experiments is believed to have a similar origin. An interesting feature is the extraordinary delicacy of the test now used for detecting gold. One of Professor Haber's collaborators suddenly found traces of gold in a material which

no one else could confirm on other samples of the material. It turned out that he had removed his gold spectacles and then grasped a strip of purest lead to put into the crucible he was using for the analysis. On another occasion some one in the laboratory was heating gold to a high temperature and shortly afterwards a worker in the next room detected this metal in a substance known to have been previously quite free from it.

H. K. M.

High Frequency or "Ironliss" Induction Furnaces. EDITORIAL. *Nature*, **117**, 760–2 (1926).—A description of the furnaces, accessory apparatus, applications in laboratory and works, together with theoretical consideration and bibliography. H. K. M.

Electrons, Atoms, and Molecules. T. M. LOWRY. *Nature* (Supplement), **117**, 33–40 (1926).—The article indicates some of the aspects of pre-war chemistry which have been transformed by the impact of post-war physics and will be of value to many of our teachers of chemistry. H. K. M.

A Hydrometer for Solids. ANON. *Sci. and Inv.*, **14**, 330 (1926).—This article describes a simple, direct-reading hydrometer for determining the specific gravity of solids which Dr. Ernest A. Vuilleumier of Dickinson College, Carlisle, Pa., recommends. The apparatus consists of a single graduated glass cylinder which is marked in such a manner that the specific gravity of ores, minerals, or other solids may be determined with ease. The cylinder is about seven inches high with a diameter of about one-fourth inch. To determine the specific gravity of any solid, 100 cc. of water are placed in the cylinder filling it to the zero mark about four inches from the base. 100 grams of the solid are placed in the cylinder containing the water. The exact specific gravity can be determined by reading the figure on the cylinder which has been reached by the water.

A solid with specific gravity of 2.0 would cause the water to rise in the cylinder a distance of 5.0 centimeters above the zero mark, while a solid with specific gravity of 10.0 would cause a rise of water of 1.0 centimeter. The secret of the device lies in a table of reciprocals of 100 as shown.

Specific gravity	Vol. of 100 gms. in ml.
2.0	50.0
2.5	40.0
3.0	33.3
5.0	20.0
7.0	14.3
9.0	11.1
10.0	10.0

W. R. W.

Some Recent Contributions of Chemistry to Medicine. EDITORIAL. *J. Am. Med. Assoc.*, **86**, 1838–9 (1926).—Much medical research at present, if concerned with fundamentals and not with purely superficial aspects, requires the resources of chemistry. Within recent years this science has aided in many of the important advances in medicine.

Among the new drugs are mentioned ethylene, sulfarsphenamine and tryparsamide. The antiseptic properties of the aniline dyes have been put to therapeutic use. Mercurochrome is also used to a great extent. The isolation and preparation of products present in a normal body and necessary to health but absent in certain diseased conditions has been brought about. Insulin is an example of this. The real nature and properties of the vitamins have also been investigated. Chemistry has also contributed toward explaining the functions and mode of action of the different elements of the body. Calcium and phosphorus are mentioned. In the explanation of oxidation and reduction by modern chemistry we have an attempt at explaining the fundamental processes of life. W. R. W.

"1000 and One Films." The Educational Screen has recently published the fourth edition of a booklet entitled, "1000 and One Films." It contains a complete reference list of films for non-theatrical use and suitable for education and entertainment. The films are listed under group titles such as Chemistry, Physics, Industry, etc. The booklet may be obtained from the Educational Screen, 5 South Wabash Avenue, Chicago, Illinois, price 75 cents.

Recent Books

Electrical Precipitation. SIR OLIVER LODGE, D. Sc., F.R.S. Oxford University Press, London: Humphrey Milford, 1925. II + 40. 7 illustrations. 15 × 24 cm. $1.00.

A lecture delivered before the Institute of Physics in London during October, 1924, the book constituting Volume III of Physics in Industry. The author presents in a very interesting general discussion the fundamental considerations bearing upon electrical precipitation, and, as Sir Oliver Lodge was one of the earliest pioneers in the study of the practical application of electrical precipitation, the book is of particular interest to all those who are interested in the art. The author divides his subject into three parts; first, natural precipitation, second, artificial precipitation, and third, the combination of the two, with suggested meterological possibilities.

Under the first heading the author discusses the forces active in bringing about atmospheric electrical charges and natural precipitation. He lays particular emphasis on the investigations conducted by Dr. George C. Simpson in his study of thunder storms. After discussing the various methods by which suspended water particles might be charged electrically, the author sets forth the conditions under which natural precipitation can take place.

In the second chapter the author gives a brief review of the history of the development of the art of artificial electrical precipitation and a brief synopsis of the practical application of the process of electrical precipitation with particular reference to the collection of acid mists and smelter fumes. The author adds a brief discussion of the carbon smoke problem existing in modern cities.

In the third chapter the author makes a forecast as to the possibilities which may result from an extension of present-day knowledge and the application thereof to the dissipation of fogs, the production of rain, and the consequent control of climate.

An Appendix of 4 pages and 7 illustrations is added, giving a brief description of the apparatus and equipment used in the application of the Process of Electrical Precipitation in a sulfuric acid plant, a tin smelting plant, and an iron blast furnace plant. WALTER A. SCHMIDT

Elements of Industrial Chemistry. ALLEN ROGERS, Supervisor of the Industrial Chemical Engineering Course and Head of the Department of Industrial Chemistry, Pratt Institute, Brooklyn, New York; Lecturer on Industrial Chemistry, Columbia University. Second Edition. D. Van Nostrand Company, New York, 1926. X + 680 pp. 138 figures. 13 × 21 cm. $4.50 net.

This book is described by the author as an abridgment of his "Manual of Industrial Chemistry," for classes lacking sufficient time to cover the more extended treatise. One familiar with the larger work, which is a collection of descriptive essays on the more important chemical industries written by specialists in each, will clearly recognize the influence of the contributors on reading this work. Consequently, this book represents the statements of authorities in each special field rather than of one man, a manifest advantage.

The discussion of the various topics is very clear, and includes as much detail as a student could be reasonably expected to learn in a year's time. Few of the chapters are long enough to tempt the student to skim over the surface, missing all but the high spots. The material presented appears to be quite up-to-date.

The reviewer feels that some subjects have been over-emphasized and others of equal or greater importance almost neglected. The chapters on perfumes and essential oils and on leather are disproportionately long, while such topics as organic solvents, synthetic dyes and drugs, and nitrogen fixation are dealt with very briefly.

The book is essentially descriptive and, as such, is quite satisfactory. It seems that a real opportunity is being lost in failing to present more definitely the application of chemical principles to industrial processes, as in the Haber process, synthetic methanol, and many other examples. Students usually miss such points unless they are forcibly presented to them and, as a consequence, fail to see the real importance of much of their college work.

The criticism offered must not be taken to mean that the book is without merit. The reviewer feels that this text is one of the most satisfactory for use in a short course in industrial chemistry, especially if the course is to be entirely descriptive. JOHN H. GARDNER

The Carbon Compounds. C. W. PORTER. Ginn and Co., Boston. Revised edition, 1926. ix + 501 pp. 15 × 23 cm. $4.00.

"This volume constitutes an outline of an elementary course in organic chemistry as presented to sophomore students in the University of California. The scope of the book is limited to a presentation of fundamental principles and general reactions. Some of the doctrines of the

electron theory; postulates concerning the origin of color; and views relating to free radicals are included. The author realizes that the conclusions upon these recent contributions may require early revision, but it is important to stimulate interest in the researches of today even if in so doing we introduce here and there a theory of no permanent value."

The book has three main divisions. The first part is devoted to the aliphatic compounds; the second deals with the aromatic compounds; and the third constitutes a review of the more important general organic reactions. An appendix discusses the determination of molecular weights. There are also over two hundred excellent questions and problems for review at the end of the book. This division makes the book more readily applicable for use in either a short or long course as the first two divisions cover the necessary work for the former.

It is unfortunate that a "revised" text coming out at this date does not mention some of the recent industrial developments, such as the synthesis of methyl alcohol, catalytic production of acetic acid and the uses of ethylene. But perhaps it is hopeless to attempt to do this in a text and such additions must be made by the instructor.

The text is weak on emphasizing the distinguishing and characteristic reactions of classes of compounds such as would be of value later if it were used as a foundation for a course in qualitative organic analysis.

The chapters presented in part three are well selected and clearly written. We believe a chapter on heterocyclic ring compounds, including such rings as the pyrrol, furfuran, and thiophene, could be added to advantage.

The chapter on "Valency," in which the electron theory is emphasized, is very good. The author states, "throughout this text we will use the term *valence* as a measure of the number of electrons an atom may yield or receive in the formation of a stable compound, or the number of pairs of electrons it may share with other atoms." This is illustrated clearly in a number of places later in the book and is doubtless the distinguishing feature of this text.

J. W. HOWARD

Catalog of Science and Technology No. III, Part VII, Chemistry. Henry Sotheran & Co., London, 1926. 207 pp. 15.2 × 21.6 cm. Paper cover. 2s. 6d.

This delightful booklet will be of interest to even the most casual student of the history of chemistry. It is no mere catalog in the ordinary sense. Of an earlier edition the *Nation* has said, "Those who find pleasure in catalogs of old books must now pay for it. The annotations alone are worth the money, for the annotator is a scholar and a bookman who seems never at a loss to add to the interest of a volume."

Some of the works listed contain the bookplates, inscriptions, and annotations of the elect. Included are "most of the books of historical importance." In the galaxy are such names as Accum, Albertus Magnus, Basilium Valentinus, Becher, Berzelius, Black, Boyle, Cavendish, Dalton, Davy, Faraday (including original manuscripts), Galvani, Geber (including Sir Isaac Newton's copy), Glauber, Hermes Trismegistus, Lavoisier, Libavius, Liebig, Paracelsus, Priestley, Scheele, and Stahl.

Most of the prices are within reach of the modest purse. But of another merit the Rambler in *The Cairo Sphinx* says, "It would be possible to dispute as to whether there is more enjoyment in the possession of books or in the buying of them; but certainly the next best thing to either is thinking of the books you might buy, and I have been revelling in the pastime for some days."

E. A. VUILLEUMIER

TO BE REVIEWED LATER

A First Book in Chemistry—Bradbury.

Exercises in General Chemistry and Qualitative Analysis—Deming and Arenson.

Physical Chemistry for Colleges—Millard.

Qualitative Analysis—Cooper.

Qualitative Chemical Analysis—Sears.

General Chemistry—The Miner Series, Joint Authors.

Electrical "Eye" Sorts Cigars by Color. Sixty times a minute a new cigar-sorting machine picks up a cigar, "looks" at it, and selects the compartment where it belongs according to the shade of its brown coloring. Mechanism then deposits it in the proper place.

The new device, which is being utilized by several prominent cigar manufacturers, is actuated by a photoelectric cell similar to those used in television. Light from the cigar falls upon the sensitive alkali, metal coating inside the cell, resulting in a shower of electrons which, properly controlled in an electric circuit, act upon a relay circuit.—*Science Service*

CONVENTIONS—GO TO THEM!

This is the month of teachers' conventions or association meetings.

By attending your state meeting is one of the best methods of keeping in touch with the progressive educators of your state. Real and lasting information will be gained as the result of acquaintances made at these gatherings.

It is an interesting and significant fact that most of the speakers on last year's chemistry teachers' association programs were regular subscribers to the JOURNAL OF CHEMICAL EDUCATION. We venture to predict that this will be true again this autumn. Further, we predict that most of those in attendance will be regular readers.

There is satisfaction in knowing that our readers are recognized leaders in chemical education.

Let us tell our friends at conventions about the

JOURNAL OF CHEMICAL EDUCATION

A CARD IS COMING TO YOU

Shortly a card will be sent you. On this card will be a list of groupings as to your possible vocation. We wish you to check the space opposite your correct vocation and then promptly return the card to us.

Why do this?

We wish to have available for each of our advertisers a sworn statement not only as to distribution of our subscribers but also a list of the various vocations to which they belong and how many of them belong to each. If you place yourself in the position of the advertiser, you will readily understand how valuable such information is.

Further

When we are in a position to give such a statement concerning the subscribers' list of the JOURNAL OF CHEMICAL EDUCATION, we immediately obtain a preferred position when seeking new advertisements. So when you receive the card, please check it and return by the next mail.